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Assessing the economics of biodiversity in Finland

National implications of the Dasgupta Review

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Abstract

"The Dasgupta Review on the Economics of Biodiversity" focuses on economic drivers of biodiversity loss and on potential economic solutions to mitigate the loss. The key message of the Review is that our demand for goods and services exceeds nature's capacity to supply them in the long term, as nature's worth to society is not reflected in market prices.

This report provides examples of the dependencies of the Finnish economy on natural assets and biodiversity, and links via which the Finnish economy impacts on local and global biodiversity. The options for change (OC) defined by Dasgupta are assessed from the national perspective: 1) Nature's supply: Conservation and restoration of ecosystems; 2) Our demand: Changing consumption and production patterns; 3) Trade and supply chains; 4) Pricing environmental damage; 5) Future population; 6) Changing our measures of economic progress; 7) Global public goods; 8) The Global financial system; 9) Empowered citizenship; and 10) Education and biodiversity.

The key policy implication is that all options for change are applicable in Finland and there are numerous policy alternatives to target biodiversity loss. National actions are needed while at the same time actively participating in international co-operation. All actors in society need to undertake actions. It is important to enhance policy measures, even with imperfect information.

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Luonnon monimuotoisuuden ja talouden keskinäisten riippuvuuksien arviointi: Mitä Dasguptan raportti tarkoittaa Suomen kannalta?

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Tiivistelmä

Dasguptan raportti (2021) luonnon monimuotoisuuden ja talouden riippuvuuksista käsittelee luontokadon syitä ja yhteiskunnallisia ratkaisuja luontokadon hillitsemiseksi. Luontokatoa edistää se, ettei luonnon todellinen arvo yhteiskunnalle näy markkinahinnoissa, eikä se siten vaikuta tarpeeksi voimakkaasti päätöksentekoomme. Tästä seuraa, että tavaroiden ja palveluiden kysyntä ylittää luonnon kyvyn ylläpitää niiden tuottamiseen välttämättömiä ekosysteemipalveluita. Raportti määrittelee kymmenen muutospolkua luonnon paremmaksi huomioimiseksi päätöksissämme.

Tämä arviointiraportti tarjoaa esimerkkejä siitä, miten Suomen talous on riippuvainen luonnonvaroista ja luonnon monimuotoisuudesta sekä siitä, kuinka Suomen talous vaikuttaa monimuotoisuuteen paikallisesti ja globaalisti. Dasguptan määrittämiä muutospolkuja arvioidaan kansallisesta näkökulmasta: 1) Luonnon tarjonta: Ekosysteemien suojelu ja ennallistaminen; 2) Kulutus- ja tuotantotapojen muuttaminen; 3) Tuotantoketjut ja kansainvälinen kauppa; 4) Haitallisten vaikutusten hinnoittelu; 5) Tulevaisuuden väestöt; 6) Luontopääoman mittarit; 7) Globaalit julkishyödykkeet; 8) Globaali rahoitusjärjestelmä; 9) Motivoitunut ja vaikuttava kansalainen; ja 10) Koulutus ja luonnon monimuotoisuus.

Keskeisin johtopäätös on, että kaikkia muutospolkuja voidaan toteuttaa Suomessa. Muutospolut tarjoavat lukuisia toisiaan tukevia politiikkatoimia luontokadon torjumiseksi. Kansallisia toimia tarvitaan samalla, kun osallistumme aktiivisesti kansainväliseen yhteistyöhön. Kaikkien yhteiskunnan toimijoiden on astuttava muutospoluille. Politiikkatoimenpiteitä on vahvistettava nykyisen tiedon pohjalta, vaikka tutkimustieto täydentyy koko ajan.

Asiasanat	luontopääoma, luonnon monimuotoisuus, talous, ekologinen kestävyys, kestävä kulutus, ekosysteemipalvelut		
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Bedömning av ömsesidigt beroende mellan ekonomin och den biologiska mångfalden: Vad innebär Dasguptas rapport för Finland?

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Dasguptas rapport (2021) av det ömsesidiga beroendet mellan ekonomin och den biologiska mångfalden fokuserar på ekonomiska drivkrafter bakom förlusten av biologisk mångfald och på potentiella ekonomiska lösningar för att minska förlusten av biologisk mångfald. Huvudbudskapet i granskningen är att vår efterfrågan på varor och tjänster överstiger naturens förmåga att tillhandahålla dem på lång sikt, eftersom naturens värde för samhället inte återspeglas i marknadspriserna. I rapporten definieras tio förändringsalternativ för att bättre beakta naturen i vårt beslutsfattande.

I denna rapport ges det exempel på den finländska ekonomins beroende av naturtillgångar och biologisk mångfald. Dessutom ges det exempel på kopplingar genom vilka Finlands ekonomi påverkar den lokala och den globala biologiska mångfalden. Ur ett finländskt perspektiv bedöms följande förändringsalternativ som fastställts av Dasgupta: 1) naturens förmåga: bevarande och restaurering av ekosystem, 2) vår efterfrågan: ändring av konsumtions- och produktionsmönster, 3) handels- och leveranskedjor, 4) prissättning av miljöskador, 5) framtida befolkning, 6) mått på naturkapitalet, 7) globala allmänna nyttigheter, 8) det globala finansiella systemet, 9) medborgarskapsinflytande och 10) utbildning och biologisk mångfald.

Den viktigaste slutsatsen är att alla förändringsalternativ kan tillämpas i Finland och att det finns många alternativa politiska åtgärder som kan minska förlusten av biologisk mångfald. Nationella åtgärder behövs samtidigt som vi aktivt deltar i internationellt samarbete. Alla aktörer i samhället måste vidta åtgärder. Det är viktigt att stärka de politiska åtgärderna, trots att den information som man utgår från är ofullständig.

Nyckelord naturkapital, naturens mångfald, ekonomi, ekologisk hållbarhet, hållbar konsumtion, ekosystemtjänster

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Contents

Summary 8

1 Introduction 10

2 Framework and key concepts 14

3 Biodiversity impacts of the key sectors in the Finnish economy 19
3.1 National footprints 20
3.2 Industrial/sectoral impacts 23
3.2.1 Food production 23
3.2.2 Use of water resources 29
3.2.3 Forestry 31
3.2.4 Sectors with land use impacts: building and traffic 35
3.3 Biodiversity footprints of households 39
3.4 Biodiversity impacts of the public sector 42

4 Biodiversity dependency in the Finnish economy 45
4.1 Biodiversity in water ecosystems and fisheries 48
4.2 Ecosystem services in agriculture 51
4.3 Forest sector 55
4.4 Recreation and tourism 58
4.5 Health and well-being 63
4.6 Existence values 66

5 Development in biodiversity and policy 70

6 Options for change: the Finnish perspective 75
6.1 Nature's Supply: Conservation and Restoration of Ecosystems
(Heini Kujala, University of Helsinki) 75
6.2 Our Demand: Changing Consumption and Production of Food Patterns
(Markus Vinnari, University of Helsinki) 84
6.3 Trade and Supply Chains
(Sami El Geneidy, University of Jyväskylä) 90
6.4 Pricing environmental damage
(Marita Laukkanen, VATT Institute for Economic Research) 97

6.5 Future Population and Option for Change for Finland
(Milla Nyyssölä, The Labour Institute for Economic Research LABORE) 100
6.6 Changing Our Measures of Economic Progress
(Johanna Pakarinen, Statistics Finland).. 108
6.7 Global Public Goods
(Nina Tynkkynen, Åbo Akademi University) 117
6.8 The Global Financial System
(Hanna Silvola, Hanken School of Economics)... 120
6.9 Empowered Citizenship
(Simo Kyllönen, University of Helsinki) 125
6.10 Education and biodiversity
(Niina Mykrä, University of Jyväskylä)... 131
6.11 Summarizing and evaluating the options for change.. 137

7 Discussion of results and policy implications.. 154

SUMMARY

In 2021, Partha Dasgupta published a monograph entitled "The Dasgupta Review on the Economics of Biodiversity". It focuses on economic drivers of biodiversity loss and on potential economic solutions to mitigate the loss. The key message of the Review is that our wealth has increased through accumulating capital goods and human capital, but at the expense of natural capital. Our demand for goods and services exceeds nature's capacity to supply them in the long term, mainly due to market distortion, as nature's worth to society is not reflected in market prices. The Review sets out ten concrete options for change (OCs) to correct the faults in the socio-economic system and better incorporate biodiversity in decision making at various levels of society.

The Review operates on the global scale. Because biodiversity and socio-ecological conditions vary, the success of biodiversity actions is sensitive to local conditions. The evaluation and implementation of the OCs suggested by the Review calls for a national assessment. In this assessment report, the Review is applied and evaluated from the point of view of one country, Finland. This report aims to find examples of the dependencies of the Finnish economy on natural assets and biodiversity, and links via which the Finnish economy impacts on local and global biodiversity. In particular, the report concretizes what the OCs suggested by the Review mean for Finnish citizens and governmental, regional and commercial actors.

The assessment was partly written by researchers reviewing the literature on the current state and partly by a scientific panel of experts that assessed the options for change defined by Dasgupta from the national perspective. Stakeholders participated widely in commenting on the OCs.

Finland's national biodiversity footprint in absolute terms is moderate in international comparisons. In per capita terms, the Finnish footprint is, unfortunately, high. It is partly outsourced to low-income countries. The key drivers of biodiversity loss in Finland, i.e., forestry, agriculture and various land use changes, and their impacts are summarized. The same sectors are also highly dependent on ecosystem services and related biodiversity. However, in many cases, it is not well known and difficult to determine how changes in biodiversity will impact on the function of ecosystems and the formation of ecosystem services and their resilience, especially in the long term.

The ten OCs presented by Dasgupta are introduced one by one, summarizing how the OC is implemented in Finland at present, and research-based ideas and views are provided on how to implement the OC more efficiently and comprehensively. The recommended policy changes are found in all options for change:

- Nature's supply: Conservation and restoration of ecosystems
- Our demand: Changing consumption and production patterns
- Trade and supply chains
- Pricing environmental damage
- Future population
- Changing our measures of economic progress
- Global public goods
- The Global financial system
- Empowered citizenship
- Education and biodiversity

The key policy implication of the assessment is that all options for change are applicable in Finland and there are plenty of policy alternatives to target biodiversity loss. National actions are needed and can be taken while at the same time actively participating in international co-operation. All actors in society can and need to participate and undertake actions. Although it is impossible to put price tags on biodiversity in its various levels and locations, its value can be identified and integrated in decision-making. It is necessary to enhance policy measures even with imperfect information and find ways to illustrate and to tolerate uncertainty before more research information is produced.

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We also thank the advisory board (Tanja Suni, Joona Lehtomäki, Pentti Linnamaa) from the Ministry of the Environment for fruitful comments.

Several experts participated in the stakeholder workshop. We thank them all for their useful comments.

1 Introduction

Human alteration of the environment has led to the loss of 83% of the wild mammal biomass and half of the world's plant biomass (Pörtner et al. 2021). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) also estimates that more than a million plant and animal species are currently threatened with extinction. Biodiversity loss is taking place at the level of habitats, species and genetic variation in Finland, as well as in other countries. It is estimated that one in nine of Finland's assessed species is endangered. Almost half (48%) of the approximately 400 habitats have been assessed as endangered throughout the country (2018). The state of habitats has not improved over the last decade and the trend in many habitats is estimated to be continued deterioration. Biodiversity is a characteristic of ecosystems that enables the supply of a wide variety of services. It enables the natural environment to be productive, resilient and adaptable. The extinction of biodiversity has negative effects on human well-being in terms of material goods and services such as food and timber, cultural services from nature such as outdoor recreation, and physical and mental health. However, our economic and social system has not been able to solve the biodiversity extinction crisis.

To focus on the possibilities of economic solutions to biodiversity loss, Partha Dasgupta prepared a monograph in 2021 entitled "The Dasgupta Review on the Economics of Biodiversity" (the Review) (Dasgupta 2021) at the invitation of the then Chancellor of the Exchequer of the UK Government. The Review was commissioned in 2019 by HM Treasury and was supported by an Advisory Panel drawn from public policy, science, economics, finance and business.

The Review has attracted considerable global interest among the scientific community, businesses, non-governmental organizations and national, as well as international institutions. In less than two years, it has collected over 700 citations in the scientific literature and millions of references in popular publications. The Review is important according to several criteria. It is valid, as it is based on the scientific literature. It is extensive, as it focuses on the global threat to the whole of humankind and Nature. Furthermore, it has high practical usability by providing recommendations that can be implemented at the policy level, as well as in individual actions.

The Review adopts an anthropocentric viewpoint by examining the value of biodiversity in terms of its contributions to human well-being. In this way, it provides the minimum value for nature; if biodiversity is worth preserving and promoting for purely anthropocentric reasons, it would be even more deserving of protection and promotion if it also had ecocentric intrinsic value.

The Review describes Nature as "our most precious asset" and finds that humanity has collectively mismanaged its global asset portfolio. The Review perceives us (all) as asset managers. Individuals, businesses, governments and international organizations manage natural assets partly unintendedly through their spending and investment decisions. The accumulation of produced material and human capital has taken place at the expense of natural capital. Economic growth has come at a cost to Nature, endangering the prosperity of current and future generations.

The Review demonstrates that our demand for goods and services far exceeds Nature's capacity to supply them in the long term. Following the argumentation of environmental economics, the Review recognizes that at the heart of the problem of the imbalance of supply and demand is an extensive institutional failure. Nature's worth to society – the true value of the various goods and services it provides – is not reflected in market prices, because much of it is open to all, at no monetary charge. These pricing distortions have led us to invest relatively more in other assets, such as material capital, and underinvest in our natural assets. Beyond this market failure, many of our institutions have proved unfit to manage the externalities.

The Review requires action now; to do so would be significantly less costly than delay. The solution that the Review presents is based on understanding that economic activities are embedded within Nature, not external to it. The Review's approach is based on knowledge of ecosystem functioning, and how it is affected by economic activity, production and consumption, which damage ecosystems and weaken their ability regenerate and to provide goods and services. Solutions are based on fully accounting for the impact of our interactions with Nature and rebalancing our demand with Nature's capacity to supply.

"The options for change" in the Review present ideas on which those applying the lessons of the Review can build. They encourage ideas and provide possibilities for transformative change. The options for change presented in the Review involve finding ways to: (i) reduce per capita global consumption; (ii) lower the future global population from what it is today; (iii) increase the efficiency with which the biosphere's supply of goods and services is converted into global output and returned to the biosphere as waste; and (iv) invest in Nature through conservation and restoration to increase our stock of Nature and its regenerative rate.

The Review focuses on universal needs and on the global scale, even though with examples it looks closely at smaller scales and local engagement with Nature. Because biodiversity varies geographically, its state will differ between countries. The success of biodiversity actions is sensitive to national socio-ecological conditions. Societies also differ in their "conception of what enables lives to flourish". Differences in the way communities can live tell us that people do not experience increasing resource scarcity in the same way. This is why the Review does not attempt to produce a "blueprint of policies appropriate in different locations". Instead, it seeks to guide the reader through the options that humanity in general has for achieving the necessary change. The evaluation and implementation of the options for change suggested by the Review call for a national assessment that considers the national ecological conditions and the dependencies of nature and socio-cultural aspects. Furthermore, national-level collective deliberation is the democratic way for not only sharing information but also coordinating decisions and enhancing actions.

In this assessment report, the Review is applied and evaluated from the point of view of one country, Finland. This report aims to find examples of the dependencies of the Finnish economy on natural assets and biodiversity, and links via which the Finnish economy impacts local and global biodiversity. In particular, the report concretizes what the Options for Change mean for Finnish citizens and governmental, regional and commercial actors. It is thus not a repetition of the Dasgupta Review but an interpretation of the generally applicable needs for changes to economic institutions to acknowledge biodiversity in a roadmap for an individual nation.

This assessment strictly focuses on biodiversity. The ecosystem services that nature provides have previously been assessed in the TEEB report for Finland (Jäppinen & Heliölä 2015). The ecological assessment of biodiversity in Finland has been implemented in the Red List of Finnish Species (Hyvärinen et al. 2019) and the Finland's Red List of Ecosystems (Kontula & Raunio 2019). Finland is currently also preparing a Biodiversity Strategy that follows the EU strategy for biodiversity.

This assessment has been written by a scientific panel of experts. The work has been supported by a steering group from the Ministry of the Environment. The suggestions by the scientific panel have been discussed together with a wide group of stakeholders from administration, non-profit organizations, relevant firms and research groups, and finalized based on their feedback.

In the following, we first present the framework and vocabulary for this assessment. Then, we review some key examples of how economic activities in Finland impact on biodiversity and what are the key dependencies of livelihoods on biodiversity via ecosystem services. The present state of Finnish and EU biodiversity policy is introduced before a national assessment of the Dasgupta-defined options for change.

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2 Framework and key concepts

The framework for this report focuses on the link between ecosystems and biodiversity and the economy and human well-being (Figure 1). Biodiversity is a multi-faceted feature of ecosystems, including variations among genes, species and habitats. Biodiversity also includes the diversity of the functional characteristics of an ecosystem's species populations. We perceive biodiversity as a key to the processes governing ecosystems.

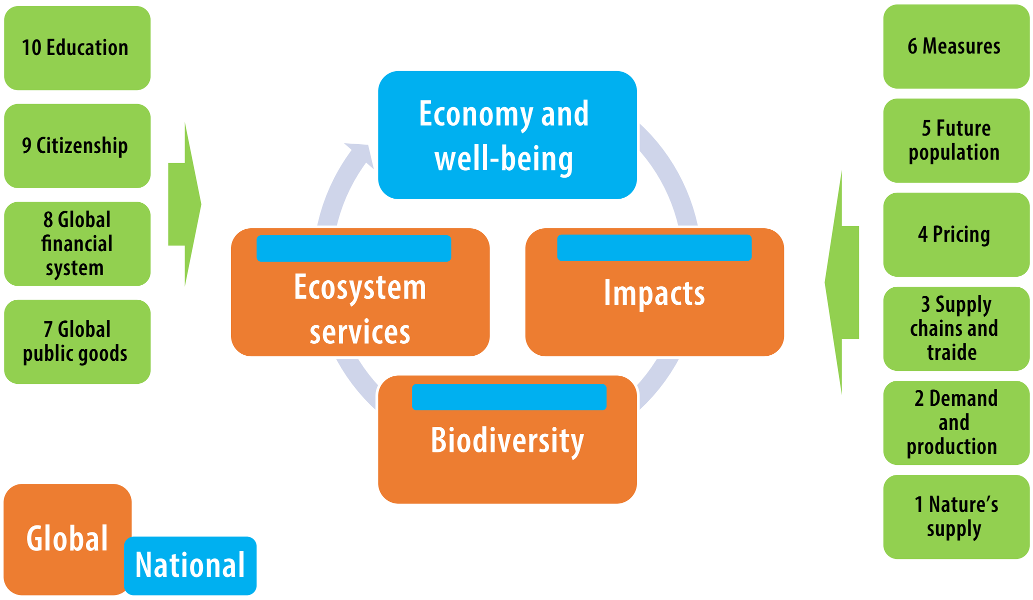
We assess the link between diverse ecosystems and the economy from two perspectives. First, we are interested in the impacts of the Finnish economy on nature. By the demand for nature, we mean the goods and services we harvest and extract from nature over a period of time and put back as waste. This is known as the ecological footprint, and here, more precisely, the biodiversity footprint.

Second, we focus on the nature's supply of various services for humans, in particular the importance of biodiversity for ecosystem services. Well-functioning ecosystems contribute to human well-being. This is typically expressed in ecosystem services: provisioning services such as fuel and fibre, regulating and maintenance services such as climate, water flow or diseases regulation, and cultural services that offer non-material benefits, including spiritual experiences and an identification with religious values. In this assessment, we focus on those ecosystem services for which changes in biodiversity would be expected to have a visible and known impact on the flow of ecosystem services to the economy and to people's well-being.

We are interested in the economy of Finland but aim to depict how consumption in Finland impacts biodiversity globally. In the contribution of biodiversity to ecosystem services, the focus is more on the national level.

In Finland, as well as globally, the impact of economic activities on nature is greater than nature's capacity to recover. This leads to inequality in the demand for goods and services from nature and nature's supply of these services and ability to recover. The **options for change** represent the actions that can be taken to balance the inequality between the demand for nature and nature's supply of goods and services. The options for change, presented in green boxes Figure 1, follow the Dasgupta Review, but are assessed in the following from a national point of view.

Figure 1. The conceptual framework.



In the following, we aim to use standard language, but we apply some key concepts from the Dasgupta review and some concepts relevant for national assessment. In the following summary of concepts, we use definitions presented by Dasgupta, if available. If the definition is from another source, a reference is provided.

- Accounting price: The contribution that an additional unit of a good, service or asset makes to intergenerational well-being, all else being equal. In simple terms, accounting prices reflect the true value to society of any good, service or asset. Also known as the 'shadow price'.
- Asset: A durable object that produces a flow of goods and/or services over time.
- Biodiversity: The variety of life in all its forms, and at all levels, including genes, species and ecosystems. The CBD defines biodiversity as 'the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems' (Convention on Biological Diversity 2022).

- Biodiversity footprint: The impact of a commodity, company, person or community on global biodiversity, measured in terms of biodiversity change as a result of the production and consumption of particular goods and services. (IEEP 2021)
- Biosphere: The living world; the total area of the Earth that is able to support life.
- Connectedness with Nature: The extent to which individuals include nature as part of their identity. Three components form the nature connectedness construct: The cognitive component is the core of nature connectedness and refers to how integrated one feels with nature. The affective component is an individual's sense of care for nature. The behavioural component is an individual's commitment to protect the natural environment (Schultz 2002).
- Cultural services: All the non-material, and normally non-rival and non-consumptive, outputs of ecosystems (biotic and abiotic) that affect the physical and mental states of people (CICES 2018).
- Ecological footprint: The Review defines the global ecological footprint as humanity's demands on the biosphere per unit of time (also referred to as 'impact' and 'demand' in the Review). The ecological footprint is affected by the size and composition of our individual demands, the size of the human population, and the efficiency with which we both convert Nature's services to meet our demands and return our waste to Nature (Review definition). The Global Footprint Network defines the ecological footprint as a measure of how much biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management practices (Global Footprint Network 2020).
- Ecosystem accounting: The integrated and comprehensive statistical framework for organizing data about habitats and landscapes, measuring ecosystem services, tracking changes in ecosystem assets, and linking this information to economic and other human activity. (UN 2022)
- Ecosystem: A natural unit consisting of all the plants, animals and microorganisms (biotic factors) in a given area, interacting with all of the non-living physical and chemical (abiotic) factors of this environment.
- Effective institutions: A concept covering rules, laws and government entities, as well as the informal rules of social interactions. Effective institutions enable people to work together effectively and peacefully. Fair institutions ensure that all people have equal rights and an opportunity to improve their lives, and access to justice when they are wronged. (OECD 2014)
- Environmental subsidy: Payment by a government to assist or improve performance regarding ecological maintenance or the protection, defence or shelter of natural resources. (EIONET 2021)

- Environmental tax: A tax whose tax base is a physical unit (or a proxy of it) that has a proven specific negative impact on the environment. Four subsets of environmental taxes are distinguished: energy taxes, transport taxes, pollution taxes and resources taxes. (Eurostat 2013)
- Environmental valuation: refers to a variety of techniques to assign monetary values to environmental impacts, especially non-market impacts.
- Externality: A positive or negative consequence (benefits or costs) of an action that affects someone other than the agent undertaking that action and for which the agent is neither directly compensated nor penalised.
- Human capital: This refers to the productive wealth embodied in labour, skills and knowledge.
- Insurance value: The value ecosystems provide by reducing the economic impact of destructive natural events such as floods or droughts.
- Market price: The price at which a good, service or asset is exchanged in a market.
- Natural capital: The stock of renewable and non-renewable natural assets (e.g., ecosystems) that yield a flow of benefits to people (i.e., ecosystem services). The term 'natural capital' is used to emphasise that it is a capital asset, like produced capital (roads and buildings) and human capital (knowledge and skills).
- Nature's supply: The biodiversity and ecosystem services that nature provides. Enhancing nature's supply includes the conservation and restoration of nature.
- Nature-based solutions: Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions. (EC 2022)
- Open access: Open to use by all free of charge, for example fisheries in waters beyond national jurisdiction.
- Option value: The value of preserving natural resources for future use even without knowing how and how likely it is that they will eventually be utilized.
- Payment for ecosystem services: A variety of arrangements through which the beneficiaries of environmental services reward those whose lands provide these services with subsidies or market payments. (WWF 2020)
- Portfolio: A grouping of assets. Assets in an efficient portfolio yield the same rate of return, as estimated by the manager, corrected for risk.
- Public goods: Goods or services that are neither rivalrous (access to a public good by any one group of people has no effect on the quantity available to others) nor excludable (no one can be excluded from access to the good).

- Uncertainty: Any situation in which the current state of knowledge is such that the order or nature of things is unknown, the consequences, extent or magnitude of circumstances, conditions or events is unpredictable, and credible probabilities for possible outcomes cannot be assigned. Uncertainty can result from a lack of information or from disagreement about what is known or even knowable.

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3 Biodiversity impacts of the key sectors in the Finnish economy

The Dasgupta Review (p. 115) states that "we harvest Nature's goods and use Nature's services for consumption and production. Fish, timber and fresh water constitute goods; whereas pollination, water purification, flood protection, and carbon sequestration and storage constitute services... We use the biosphere as a sink for our waste products."

The impact of the economic activities on biodiversity is measured with the biodiversity footprint. The biodiversity footprint is defined as "The impact of a commodity, company, person or community on global biodiversity, measured in terms of biodiversity change, as a result of production and consumption of particular goods and services". (IEEP 2021). There is no general agreement on how to measure the biodiversity footprint for various levels of economic activity. However, it can be summarized that the biodiversity footprints measure impacts based on consumption, trade or production.

In the following, the national footprint of Finland is discussed based on consumption-based analysis. Production-based thinking is applied in the chapters on the biodiversity impacts of various sectors of the economy (3.2). In the chapters on household (3.3) and public sector impacts (3.4), the discussion starts with consumption-based figures but shifts to the opportunities of these agents to support biodiversity in their actions.

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3.1 National footprints

A group of studies have analysed national biodiversity footprints by also considering international trade (Bjelle et al. 2021, Marquardt et al. 2019, Wilting et al. 2017, 2021). These studies focus on consumption-based footprints, i.e., the impact of consumed commodities on biodiversity, regardless of the location of the impact. This means that via the production chains and trade, part of the impact occurs in other countries, but is accounted to that country where final consumption takes place. These studies make it possible to compare footprints between countries and regions. Some of them have separated the footprint into the national share and international share or into various commodity classes. They have also analysed the development of footprint temporally and explained the footprint and its changes with various social and economic factors.

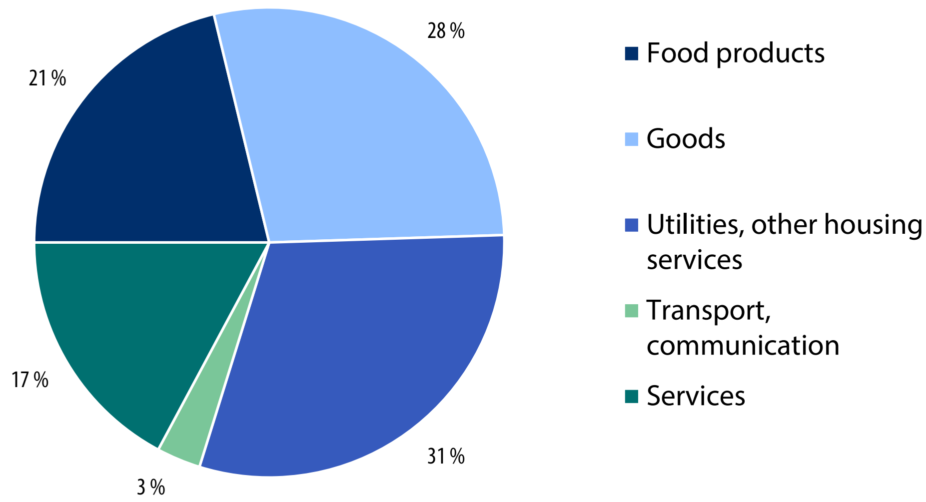
Multi-regional input–output (MRIO) analysis has been suggested as an appropriate tool to estimate national biodiversity footprints based on the consumption of goods and services (for a review, see Bjelle et al. 2021; Crenna et al. 2020). The approach takes into account the consumption of goods and services produced in different regions of the world and the import of products as both intermediate and final goods. MRIO databases have been connected to various measures of biodiversity loss (the IUCN Red List of threatened species, the potentially disappeared fraction of species (PDF), bird species lost or mean species abundance (MSA), relative abundance (RA), relative within-sample species richness (RWSR), vulnerability-weighted global relative species richness (VGRS)) in order to provide insights into the effects of trade and consumption.

The results for Finland, which can be found from the supplementary material of the studies, in many cases indicate a relatively high footprint. However, the biodiversity footprint of Finland is highly dependent on the biodiversity indicator. This complicates the ranking of countries and the comparison of indicators between countries. In particular, per capita measures indicate a high footprint for Finland. Bjelle et al. (2021) applied the potentially disappeared fraction of species (PDF) and presented country-specific biodiversity footprints per capita for 2015. Based on these, Finland is ranked in the middle range of the 214 countries or regions included in the comparison. The MSA (mean abundance of original species in a disturbed situation relative to their undisturbed abundance) per capita reported by Wilting et al. (2017) for 45 countries and world regions and (2021) for 27 EU-countries revealed the highest or almost the highest biodiversity footprint for Finland. High per-capita footprints were also found for other high-income countries, including Canada and the US. The MSA indicators emphasize biodiversity footprints from providing infrastructure for countries with an ample natural area and without other drivers of biodiversity loss, such as Finland, Sweden and the Baltic countries.

The studies demonstrate how the biodiversity footprint of consumption is distributed between one's own country and other countries around the world. Wilting et al. (2017) reported an imported share of the biodiversity footprint of 30% for Finland. Marquardt et al. (2019) demonstrated with MSA, RA and RWSR indicators that for Finnish consumption, the share of the imported footprint is around 45%. The share of the imported footprint (MSA) also varies between regions of Finland, from 32% in northern Finland to 83% in Åland (Wilting 2021).

Some studies have determined the footprint according to consumption categories. Figure 2 presents the footprint by consumption category in Finland according to Marquardt et al. (2019).

Figure 2. National biodiversity footprint of consumption in Finland in different consumption categories according to Marquardt et al. (2019) based on relative abundance (RA) indicator.



In the study of Wilting et al. (2021), Finland was among the countries with the largest intra-country variability in regional footprints. Eastern Finland was the region with the lowest per capita biodiversity footprint in Finland (1.5 MSA loss/ha), but it was higher than the per capita biodiversity footprints in all regions in the other countries of the EU-level study. For northern Finland, imported share was below 25% (hence the domestic share above 75%), partly because of a high rate of self-sufficiency in wood consumption.

Bjelle et al. (2021) reported a difference in the biodiversity footprint between various levels of income. Their findings suggest that in high-income regions from 2005 to 2015, there was strong outsourcing of biodiversity loss to low-income countries. In high-income countries such as Finland, if consumer income increases by one per cent, the biodiversity footprint increases by more than one per cent. The increased footprint particularly focuses on manufactured products, clothing and footwear, as well as housing, giving indications for areas of mitigation strategies targeted at consumers in high-income countries.

Wilting et al. (2021) found no evidence that the total per capita land-based biodiversity footprint is related to per capita GDP or income equality. However, they observed that an increase in income coincides with a decrease in the domestic biodiversity footprint, but an increase in the biodiversity footprint exerted abroad. Similarly, a high population density in a region associated with high biodiversity loss outside the region. Wilting et al. (2021) reported that Finnish households are responsible for over 80% of the national consumption-based biodiversity footprint.

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3.2 Industrial/sectoral impacts

3.2.1 Food production

Food production is comprised of terrestrial agriculture, aquaculture and capture fisheries. Most regions in Europe have had some forms of agricultural practices for nearly 7 000 years (Diamond 2002). In Finland, the earliest signs of agriculture date back 6 000 years (Alenius et al. 2012). The introduction of domesticated animals and cultivated plants and their interactions with native species have permanently changed our landscapes and habitats. Agriculture is an integral part of our terrestrial environment and the biodiversity it hosts. However, the pressure imposed by the present-day population and its consumption patterns is unprecedented. Agriculture thus both supports and threatens biodiversity. Supply chains connect Finland with regions across the globe, as we import animal feed and food products. We should consider the impact of agriculture on biodiversity in Finland and globally.

Today, about half of Earth's habitable land is allocated to agriculture (Ritchie & Roser 2013). In Finland, agriculture uses about 2.3 million hectares (about 0.4 ha per individual), which is approximately 7.5% of the land surface (OSF 2022a). Globally, 70% of grassland, 50% of savanna, 45% of temperate deciduous forest and 27% of tropical forest have been turned into agricultural land (Foley et al. 2011). This underlines the differences between the biodiversity impacts of agriculture in Finland and abroad.

The effects of agriculture on biodiversity are driven by land use and production practices. Land allocated to agriculture has replaced the natural habitats in these locations. Production practices such as the use of pesticides and fertilizers affect the polluting outputs, which have negative effects on biodiversity. Then again, agricultural landscapes provide important habitats: many of the critical terrestrial habitats in Finland depend on traditional agricultural practices, mainly on foraging livestock (Kontula & Raunio 2018).

Europe as a whole exemplifies the effect of increasing income on local versus distant effects on biodiversity, as pointed out by Wilting et al. (2021). From 2000 to 2020, the amount of land allocated to agriculture in the EU 27 countries decreased by over 10% to about 164 million hectares (FAO 2022a). The trend is expected to continue. Most of the land will turn into unutilized, i.e., abandoned land. Only about 13% is expected to be turned into forests or natural areas and about 0.4% into constructed areas (Castillo et al 2018). In the tropics, on the other hand, agricultural land has increased substantially, and about 80% of new croplands have replaced forests (Foley et al. 2011). At the same time, the import of, for instance, feed and fodder to the EU27 has increased by 35% (FAO 2022b).

The total acreage of agricultural land in Finland has remained relatively stable from 2000 to 2020. At the same time, our import of feed and fodder has approximately doubled from a little over 350 million kg to around 650 million kg (to help perceive and compare the quantities, this would be an increase from 65 kg to 120 kg per person) (OSF 2022b). Nevertheless, the vast majority of feed is produced domestically.

In terms of weight, grass and silage are the dominant forms of feed: their harvest is equivalent to over 3 100 kg for each Finn. We need more animal feed (388 kg per person, excluding grass) for domestic meat production than we consume directly as non-meat products (352 kg). Barley is the most important grain used for feed. Altogether, in 2021, domestic grain feed production totalled 307 kg per person (OSF 2022c). Although the precise value varies and is difficult to estimate exactly, more than half of our agricultural land is allocated to feed production: 37% of the grain harvest (47% of land is allocated to grain) is used directly as feed and practically all grass (35% of land allocated to grass) (OSF 2022d and OSF 2022e). The most important imported feed products are turnip rape and rape (import 14 kg per capita), fish (11.4 kg) and soybean (5.1 kg). We import more sugar and rape than we produce, and practically all our fruit is imported. The scope of feed production highlights the high potential impact of changes in our food consumption on global biodiversity (see section 6.2).

Finland thus outsources a part of the biodiversity effects of agriculture to other countries. The effects are due to both land use and less stringent and weakly enforced regulation on the use of pesticides in many of the developing, exporting countries (Handford et al. 2015). Sandström et al. (2017) estimated that as much as 93% of the biodiversity effects of agriculture are outsourced to other countries. It should be noted that their result hinges on the LCA –methodology, which emphasizes the risk of extinction of endemic mammal, bird, amphibian and reptile species. In Finland, such a risk is non-existent, since there are no endemic species, which automatically increases the relative biodiversity impact outside our borders to dramatic levels.

However, the indirect biodiversity effects of agriculture are also notable. Agriculture is the most important anthropogenic source of nutrient loading to surface waters in Finland (Sonesten et al. 2018). Excessive loading of nutrients causes eutrophication in surface waters. This destroys the more scare, oligotrophic habitats and their characteristic species, as has happened in the Baltic Sea (Ojaveer et al. 2010). Temporarily, eutrophication of an oligotrophic system may lead to increased levels of biodiversity (Heino et al. 2009).

Segregation of crop and animal farming regions has contributed to local biodiversity losses. Protecting and promoting biodiversity is more difficult in intensive, specialized farming regions than in regions with mixed farming and different land use types (Tiainen et al. 2020). Grazing is a crucial component in many of our endangered habitats (Lehtomaa et al. 2018).

The key policies to protect and promote agricultural and agriculture-impacted biodiversity are embedded in the Finnish Agri-Environmental scheme of the EU Common Agricultural Policy (CAP). The scheme comprises cross-compliance conditions common to all member states. Specific to Finland and Finnish biodiversity are the environmental agreements on establishing and maintaining wetlands, maintaining traditional rural habitats and set-aside fields for geese and other birds, and maintaining the genetic pools of native domestic animal breeds and crop varieties. Mitigating nutrient loading is one of the key targets of the scheme. As eutrophication is one of the key drivers of biodiversity loss in surface waters, almost all measures in the scheme influence biodiversity at least indirectly.

It is important to note that an influential component of the CAP is the basic income subsidy, including the LFA payment and various nationally defined and paid subsidies. Of the EU countries, Finnish agriculture is economically the most dependent on subsidies (Niemi & Väre 2019). Therefore, CAP support as such is important in maintaining the scope of agriculture, i.e., the number of animals and the total area. These are drivers of the biodiversity effects, of which the indirect ones are central for domestic agriculture. CAP thus both aggravates and mitigates the biodiversity effects of agriculture. The package of incentives influencing agricultural producers' choices should be systematically analysed and revised from the perspective of biodiversity (see Viitala (2022) for an analysis from the climate change mitigation point of view). This is particularly true in Finland, where the agricultural land area has slightly increased while it has decreased elsewhere in the EU. This would not have happened without area payments under the first pillar of the CAP.

Annual aquaculture production is approximately 15 million kg, and fisheries landings total about 164 million kg (OSF 2020). Aquaculture has direct and indirect biodiversity effects. Indirectly, it may help reduce pressure on wild, potentially overharvested fish populations and thereby support biodiversity. Its most direct effect comes from nutrient loading, which contributes to eutrophication, with the aforementioned effects on biodiversity (Diana 2009). Aquaculture's total contribution to anthropogenic nitrogen and phosphorus loading to the Baltic Sea is 1% and 2%, respectively. Locally, however, the impact may be stronger. In the Archipelago Sea, for instance, aquaculture contributes 8% of phosphorus loading (SYKE). Aquaculture generates point-source pollution. Along with other point sources, it has been able to reduce its nutrient loading so that the loading is currently less than half of the levels in the 1990s, despite production having remained on a relatively stable level (OSF 2022f).

Farmed fish may also spread diseases, weakening wild fish populations, and escaped individuals may breed with wild populations, causing genetic alterations (Diana 2009). This problem has been of particular concern in Norway (Olaussen 2018). This is important for our biodiversity footprint. In 2021, we imported 90.5 million kg of fish and fish products while we exported 72 million kg (OSF 2022g). However, our domestic production, from which the local biodiversity effects come, was only 14.4 million kg. Most of our imports are based on fish from abroad, with salmon grown in Norway comprising half of our imported fish quantity (OSF 2022h)

In 2021, we consumed about 24 million kg of imported wild fish and about 11 million kg of imported wild and farmed shrimps and other sea food. The consumption of canned tuna, for instance, was nearly 8 million kg (OSF 2022i). The biodiversity effects from these are felt outside Finland.

There are approximately 4 700 different fisheries globally, out of which 32% are in good ecological condition. However, more than half are overfished (Costello et al. 2016). Unintended bycatch weakens the populations of other fish species, marine mammals and seabirds. Certain porpoise and dolphin species are facing an imminent threat of extinction because of unintended effects of fishing (Burgess et al. 2018). Bottom trawling is widespread and detrimental to seabed habitats. Depending on the gear and exact technology, it might take up to six years before the affected habitats recover after trawling (Hiddink et al. 2017).

An emerging biodiversity concern related to fisheries is the abundance of so-called ghost nets, i.e., intentionally or unintentionally abandoned fishing gear. Modern gear can last up to 600 years in the marine environment (Macfadyen et al. 2009). Globally, about 640 000 tons of fishing gear is estimated to have been lost, creating a massive and long-lasting contribution to the marine litter problem (Stelfox et al. 2016). The recent EU directive on port reception facilities for the delivery of waste from ship (2019/883) aims to mitigate this problem. In Finland, Natural Resources Institute has initiated the follow-up and reporting of the passively fished waste connected to the directive in 2021.

In Finland, commercial fisheries are mostly focused on vendace and pikeperch in inland waters, and herring and sprat in the Baltic Sea (OSF 2021a, OSF 2022j). The Finnish quota for herring has come down significantly in recent years. There has been an approximately 40% decrease in the herring quota from 2017 to 2022, indicating changes in biological productivity and/or fish mortality.

Domestic fisheries are regulated by the EU and national regulations. Marine protected areas would be an effective means of safeguarding biodiversity and would also promote the economic profitability of fisheries by supporting fish populations (Sala et al. 2021). The EU Nature Restoration Law will mandate covering at least 20% of marine areas with nature restoration measures.

The biodiversity effects of imported fish can be managed by consumption choices (see Chapter 6.2) and supply chain management (see Chapter 6.3). There are various guides (e.g., WWF Kalaopas) and certificates (e.g., MSC) to assist in purchasing sustainable seafood.

Irrigation and water use are important drivers of the biodiversity effects of food production. In Finland, precipitation exceeds evaporation, and irrigation is limited to certain specific crops. These are discussed jointly with other uses of water and their biodiversity impacts in the following subsection.

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3.2.2 Use of water resources

About 69% of global freshwater use is devoted to agriculture, mainly for irrigation, generating negative externalities (FAO 2020). Irrigation affects the timing and quantity of water flow in rivers, typically reducing it during heat periods when the natural flow is already at its lowest. It may also lead to salinization of soils, impeding the ecosystem services that soils provide in the long term. It also lowers groundwater tables, increasing the scarcity of water and causing saltwater intrusion in coastal areas (Mateo-Sagasta et al. 2018). On the other hand, irrigated agriculture is roughly twice as productive as non-irrigated, hence reducing the need to extend agricultural land (World Bank 2022). In Finland, the effects of irrigation are mainly felt outside our borders, inflicted by our consumption choices. However, there have been some local conflicts between inexpensive irrigation water for golf courses and river biodiversity (see, e.g.: https://www.hs.fi/kaupunki/art-2000004726066.html)

Globally, many irrigation externalities are coupled to the damming of rivers. As Finnish agricultural crops are typically rain fed, our dams have mostly been constructed for other purposes. Initially, typical structures were small mill dams that did not necessarily block the rivers entirely (Hilden & Rapport 1993). From the 18th to the end of the 19th century, the government mandated and promoted extensive projects to clear rapids and lower the water tables of lakes, and even completely dry them up for flood control and to obtain fertile land for cultivation (Säisänen 1992). Extensive draining of peatlands and wetlands for agriculture and forestry was promoted by the government during the 20th century (Ojanen et al. 2020). This disrupted water flows and deteriorated water quality, both of which have negatively affected river biodiversity. Additionally, in the 20th century, larger hydropower dams and flood control structures were built, making most of our rivers completely inaccessible for migratory fish. Our river ecosystems and thereby lake, coastal and marine ecosystems have thus been extensively modified and even destroyed for a long time through the utilization and control of water for economic purposes.

Freshwater lakes, reservoirs and rivers cover about 2% of Earth's surface. Nevertheless, they host about 10% of known animal species (Reid et al. 2019). As habitats, freshwater ecosystems are among the most threatened ones (Higgins et al. 2021). River biodiversity is particularly heavily affected among freshwater systems (Vörösmarty et al. 2010, Tockner et al. 2011). This is a global phenomenon and unfortunately also applies well to Finland.

The biodiversity effects gaining most attention have been the population collapses of migratory fish: salmon, eel, lamprey and trout. These are valuable for citizens as such (Artell et al 2022). The viability of species such as brown trout is also correlated with overall river habitat quality (Törnblom et al. 2017). Their presence can thus be viewed as an indicator of the overall health of river biodiversity.

In Finland, there are approximately 220 professionally operating hydropower plants, some 500 facilities that mainly produce electricity for households, and around 4 500 smaller dams built for other purposes than hydropower (VESTY 2022). In addition, there are tens of thousands of culverts that generate obstacles of some kind for river ecosystems, but there is no detailed information on these.

The permits for some structures require mitigation of their harmful effects on biodiversity. However, even medium-sized hydropower facilities might not have any environmental requirements, and many of the required mitigation measures have not actually been enforced (Iho et al. 2022; Belinskij and Soininen 2017). The key programmes to promote river biodiversity in Finland are the HELMI programme, focusing on headwaters and small barriers, and the Nousu programme, focusing on large barrier removals and by-passes. The EU Nature Restoration Law requires the removal of river barriers to restore at least 25 000 km of free-flowing rivers by 2030.

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3.2.3 Forestry

The forest industry is one of the main manufacturing sectors in Finland. In 2021, the share of forest industry products in Finland's export of goods was approximately 20%, and the total value was 13.1 billion euros. The Finnish forest industry mostly uses domestic wood, and the direct biodiversity effects of the sector thus mostly occur in Finland. In 2021, domestic wood accounted for 86% of wood used, and as imports from Russia have further declined in 2022, domestic wood has supplied an increasing share of all wood used. The import of forest industry products to Finland is minor compared to export.

Globally, the demand for forest industry products is mostly increasing, an exception being the demand for printing and writing paper. Among the main drivers of global demand are population growth, a rise in income levels and demographic changes. As income levels have risen, for instance, in emerging economies, the demand for forest industry products, such as hygiene products and packaging solutions, has also increased.

Forest industry products produced in Finland are to a large extent exported (e.g., paper and paperboard ca. 95%, sawnwood ca. 75%). Thus, the driving force for harvesting in Finnish forests and for the use of Finnish wood is consumption outside the country and the end-users' needs and preferences there. The main export destinations are other EU countries (especially Germany) and the UK (paper, paperboard, pulp, sawnwood), China (pulp) and North African countries (sawnwood). As the fibre characteristics of boreal conifers differ from those of their southern counterparts and even more from eucalypts and other broadleaved trees, the use of boreal wood is, at least at the moment, only partly replaceable with production elsewhere.

Investments in forest growth in Finland have been significant since the 1950s. The stock volume of Finnish forests increased from 1 500 mill. m^3 in the 1950s to 2 500 mill. m^3 in the 2020s (Finnish Statistical Yearbook of Forestry 2021). At the same time, harvesting levels have also significantly increased. Despite the increase, the harvesting level has still at national level been below the maximum sustainable harvesting level when the sustainability of wood production is considered. However, when other sustainability aspects are considered, or some heavily harvested regions instead of national level, the overall view is not as positive. The ditching of mires has been extensive and has led to significant changes in peatland ecosystems. There have also been changes in tree species composition, as Scots pine and Norway spruce have earlier been favoured over deciduous trees, and changes in age structure, which have also had a negative impact on forest biodiversity, as the share of old growth forests (141+ years) has particularly declined (Finnish Statistical Yearbook of Forestry 2021). According to the 2019 Red List of Finnish Species (Hyvärinen et al. 2019), approximately one third of Finland's endangered species live in forests. Forestry (loss of deadwood and old growth forests, forest management) is the main reason behind the biodiversity loss in forests. As forestry land (also including poorly productive land) covers 86% of the Finnish land area, changes in forest biodiversity have significant impacts on the general state of biodiversity in Finland. Ditching has also contributed to the loading of nutrients and organic matter to surface waters (Nieminen et al. 2021). This has similar indirect biodiversity effects in freshwater ecosystems as agricultural nutrient loading.

Forest conservation in Finland has been advanced using both EU and national instruments. Despite positive changes in some components of forest structure, the general state of forest biodiversity (Red List Index value) has not improved (Hyvärinen et al. 2019). The quality of nature-oriented management in commercial forests has declined during recent years (Siitonen et al. 2020). Nature-oriented management is a general term for measures that aim at objectives parallel to wood production in forest management, and it includes e.g., operations aiming at the protection of key biotopes and securing small water beds and the water table, a preference for mixed forests, and the retention of living trees and deadwood (Koivula et al. 2022).

Since the 1990s, biodiversity has been better included in Finnish forest policy. Silvicultural practices and guidelines have been modified accordingly, and forest legislation has been renewed several times to better account for biodiversity. Nevertheless, for example, the latest renewal of the Finnish Forest Act (2014) has had conflicting impacts on biodiversity conservation. Kniivilä et al. (2020) demonstrated that this law has actually had negative impacts on biodiversity in certain ecosystems, e.g., on stream ecosystems, due to changes in forest management in these areas. The law renewal enabled the use of continuous-cover forestry, which has since also been advanced in several EU regulations on biodiversity and climate grounds. However, this management system is not yet widely used and its long-term impacts on biodiversity are ambiguous because of the lack of monitoring over multiple logging entries or longer time period (30–80 years) (e.g., Siitonen and Koivula 2022). Similarly, there is no unambiguous answer to the question of whether even-aged forestry or continuous-cover forestry is better from the perspective of carbon sequestration and carbon storage (Repo et al. 2022). However, on drained eutrophic peatlands, continuous-cover forestry appears to be a promising management system, as by implementing this, it is possible to slow down the reduction in peat storage over the long term.

Possible ways to improve the biodiversity of forests include increasing the number of deadwood and old trees in commercial forest stands. Favouring mixed forests would have positive effects on biodiversity, as would also wider buffer zones in the vicinity of water bodies. By habitat restoration, which will in the coming years increasingly take place as the EU Biodiversity Strategy is implemented, it is possible to return conditions that are favourable for rare and red-listed species. At the regional and national levels, it would be important to increase the proportion of old-growth forests, especially in southern

Finland. While the resilience seems to be determined by the diversity of tree species in the forests, it could additionally depend on complex biological interactions and the diversity of other species groups, based on many positive relationships between their richness and ecosystem services, although currently these pieces of evidence are often correlative (see below).

Many of the measures mentioned above result in increasing costs from the point of view of forestry. The most obvious increase in costs occurs when forest areas are strictly protected (no forestry operations allowed) or if harvesting amounts per hectare are significantly reduced, e.g., due to changing forest management practices. At the level of the national economy, the decreasing availability of wood may in the longer term decrease the industrial production, at least if the production structure remains similar to the current one. Despite the likely increasing costs, improving the state of biodiversity is also important for the forest industry and forestry in order to maintain the general acceptability of the sector and in order to be more resilient in possible future changes in environments, conditions and societies.

As 60% of forest land in Finland is owned by private persons, the goals of this group for their forest ownership have a significant impact on Finnish forests. According to Karppinen et al. (2020), the goals and preferences of forest owners are heterogeneous, and many forest owners are multi-objective, i.e., economic, recreational and ecological values are all important to them. To support the provision of biodiversity and carbon benefits of private forests, new incentive schemes would be needed. Juutinen et al. (2021) found that many forest owners would be willing to participate in a specific scheme supporting biodiversity and non-market ecosystem services. In a choice experiment ran by these authors, non-profitability factors, including biodiversity, carbon stock and probability of climate change-induced damage, were found to be important for forest owners. On average, forest owners asked for a reasonably high fee for this type of contract-based forest management. However, as preferences of forest owners are heterogeneous, a segment of them are likely to be willing to make contracts at lower compensation levels (Juutinen et al. 2021).

Currently, private forest owners may receive financial support from the state for forest management and for development and nature-oriented management in commercial forests. Public funding is based on the Act on the Financing of Sustainable Forestry (KEMERA). The general objectives are to increase the growth of forests, maintain road networks for forestry purposes, secure the biodiversity of forests and promote the adaptation of forests to climate change. Nature-oriented management in commercial forests is advanced through environmental support and nature-management projects. According to Viitala et al. (2022), more than 80% of funds in the above-mentioned scheme are allocated to supporting wood production, and the share of environmental subsidies in the scheme is small. However, other schemes also support forest and nature protection, notably the METSO and HELMI conservation programmes, but in the METSO programme, for example, funding has been considerably lower than the landowners' willingness to participate in the programme.

A new incentive scheme for private forestry is currently under preparation and will come into force in 2024. According to the Ministry of Agriculture and Forestry of Finland, the aim of the incentive scheme is to promote economically, ecologically and socially sustainable management practices in private forests. The incentive scheme will include economic support e.g., for the tending of seedlings and young stands, remedial fertilisation, peatland forest management planning and water protection, and maintaining the forest road network. Forest nature management and prescribed burning can also be subsidized. Nature management in commercial forests is advanced through environmental support and forest nature management projects, but the focus in the new incentive scheme is still clearly on wood production. According to Laturi et al. (2021), who evaluated the new incentive scheme, funding of the system should be more clearly directed to the types of work that support the ecological sustainability of forestry. Even though the support for environmental work will increase in absolute terms in the new scheme as compared to the current funding scheme, the share of environmental support in the total scheme will decrease. In the future, the incentive scheme should be further developed so that forest owners have real incentives to produce biodiversity and climate benefits (see, e.g., Lehtonen et al. 2022). Payments should be based on actual performance.

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3.2.4 Sectors with land use impacts: building and traffic

Globally, the change in land use presents the greatest immediate threat to biodiversity and could lead to changes in the way ecosystems function, as well as to considerable species extinctions (UNEP 2023). In developed countries, urbanization is typically the dominant land use change. In Finland, the number of inhabitants in urban areas has grown significantly faster than that of the country as a whole, and housing and other infrastructure have been built for the use of those who have moved to urban areas. The greatest pressures of land use change on Finland's nature arise from the expansion of the built-up structure for settlement and industry, the construction and maintenance of traffic networks and the infrastructure for energy production. The transition to renewable energy sources will require a significant increase in land area, for example, for wind power generation and the use of energy transmission infrastructure. In addition to the direct land-use effects of construction, the acquisition of raw materials and energy sources from, for example, forests, mines, soil extraction sites or from oil drilling requires the exploitation of land and marine areas (Viertiö et al. 2022).

In the 2010s, about 14,000 ha of the forest area was deforested annually in Finland (Assmuth et al. 2022). Half of this deforestation is construction-related and about a third is agriculture-related. In recent years, net deforestation, that is, the reduction in the land area of the forestry sector, has been 7,500 ha per year. Deforestation due to construction peaked in the 2000s and early 2010s. According to projections (Assmuth et al. 2022), it will remain at the level of about 12,000 hectares annually until 2030 and decrease thereafter. Deforestation due to construction is estimated to be around 8,000 hectares per year in the 2020s and will decrease to less than 6,000 hectares annually by 2040. Deforestation due to construction is concentrated in southern Finland, and consequently in more nutrient and species-rich forest types than average. These forests host considerably more red-listed species than the average forest (Hyvärinen et al. 2019), and the network of protected forests is particularly sparse in the south (Kotiaho et al. 2021). Therefore, if the intention is to nationally secure all forest species, conservation efforts would be particularly important in these nutrient-rich forests.

Other changes in land use are smaller: the annual conversion of farmland for construction has been well under 1,000 ha and the uptake of wetlands for farmland slightly less than 1,000 ha. Projections suggest that field clearing on mineral land will be maintained at an annual rate of about 1,400 hectares and peatland at just over 1,000 hectares per annum (Assmuth et al. 2022).

Finland is estimated to use between 130 million and 150 million tons per year of soil materials, mainly gravel, sand and rock rubble (Ministry of the Environment 2020). This figure is among the highest in the EU relative to the population. Finland is self-sufficient in the use of soils. Soil use volumes are significantly impacted by economic fluctuations. Although the extraction of soil is permissible, it has many effects on the environment. Adverse environmental impacts tend to be greatest during admission and can be reduced by good planning and the implementation of admission. It is possible to increase the recycling and reuse of soil substitutes, but they cannot completely replace natural soils, and thus there is already a scarcity of natural gravel in the proximity of large population centres. Careful planning and implementation, as well as after-care with an emphasis on biodiversity, can reduce the impact on biodiversity.

Apart from habitat conversion, traffic also impacts on the environment and biodiversity. In marine areas, biodiversity is protected with a network of various types of protected areas in which economic activities are restricted. Natura 2000 areas may limit the extraction of sea sand and gravel, dredging, building on and draining coastal areas, fishing, hunting, aquaculture projects, offshore wind projects, and boat traffic and beaching. National parks forbid any economic activity that may threaten the environment. Moving around is prohibited in seal protection areas from February to mid-June, and close to islets around the year. Other national and private nature-protection areas, as well as nature reserves (Naturreservat) in the Åland islands, limit human activities typically related to boating, fishing and going ashore. HELCOM Marine protected areas prompt spatial plans that reconcile the economic activities and biodiversity. Geographically, they mainly overlap with the Natura 2000 network. The VELMU programme supports the planning of marine protection, partly by providing information on underwater biodiversity (https://www.ymparisto.fi/velmu).

The importance of green spaces, ecological corridors and nature-based solutions is also acknowledged in EU decision-making, both in combating climate change and in safeguarding biodiversity in built-up environments. The aim of the EU Biodiversity Strategy is to strengthen EU-wide green infrastructure. The EU Biodiversity Strategy includes specific objectives for urban green areas and related biodiversity. All cities and municipalities with a population of 20,000 or more are encouraged to make a greening plan (Kärkkäinen & Koljonen 2021). Greening refers to the addition of diverse and accessible urban forests, parks and public gardens, urban farming (including allotment gardens and crop plots), vegetable roofs and walls, street trees, urban meadows and hedgerows. Another feature is to improve the connectivity of green spaces. As part of the implementation of the objectives of the EU Biodiversity Strategy 2030, the Commission has set up the EU Urban Greening Platform to promote the introduction of best practices in green design in cities and to form generally accepted best practices. The EU Restoration Regulation may also affect land use in cities, as it sets goals for avoiding the net loss of green areas, as well as for the canopy cover in urban areas and for increasing the percentage of green areas.

Provinces, municipalities and cities play a key role in securing biodiversity, green and blue infrastructure and connectivity through land use planning. Under the Land Use and Construction Act, zoning and other land use guidance aims to influence the supply of nature and of biodiversity. For the protection of biodiversity and the restoration of nature, planning is needed at the regional level, where the activities of different land use sectors are combined. In addition to reducing negative natural impacts, land use planning can increase positive natural impacts through various construction solutions and green space solutions. These include nature-based solutions, ensuring green lanes and ecological corridors for the built environment, and green roofs in buildings. The reformation of the Land Use and Construction Act aims to further strengthen the consideration of biodiversity in land-use planning. Improving the quality of construction reduces the pressure on nature. The safeguarding of biodiversity can be strengthened by specifying the requirements that land-use plans require to contain in order to be lawful (Saarela et al. 2020).

The value of urban green space can be defined with a hedonic pricing method that identifies the share of green space from apartment or estate prices. The results from Finland indicate that green areas have a positive effect on apartment prices (Tyrväinen 1997, Votsis 2017). In the case of green roofs, the scenic benefits can be a significant attribute in cost–benefit calculations. However, the level of benefits strongly depends on the green roof design (Nurmi et al. 2016). Participatory and deliberative approaches can provide one solution to integrate value information in planning (Ch. 6.9).

A number of tools have been launched to support land use planning, such as the Green Factor Tool or Zonation, which can be used to safeguard the amount of green space and to target the resources to various green spaces effectively. Also, other means may encourage the preservation and enhancement of natural values, such as ecological compensation (see Nature Conservation Act), where harm to nature by human activities is credited by increasing biodiversity somewhere else (e.g., Hiedanpää et al. 2021). A wider use of nature-based solutions, for example in stormwater management, also diversifies habitats. Along with water retention, stormwater or green roofs provide room for diversity (Paloniemi et al. 2019). These solutions can be evaluated on a case-by-case basis, for example using the cost–benefit analysis (Juvonen et al. 2023). Built environments that are planned and constructed to support biodiversity can serve as secondary habitats for many rare and red-listed species.

When designing and implementing traffic networks, negative environmental impacts are best avoided by refraining from extending the traffic network in question. When the benefits of new traffic routes exceed the costs, including those related to nature and the implementation proceeds, diversity can be taken into account in the design. Negative environmental impacts occur through the loss of uncovered land surface, fragmentation, interruptions of animal routes, and a reduction in soil and air quality (Sahramaa 2022). Careful planning can reduce the fragmentary effects of traffic routes on natural areas. Roadside verges can function as surrogates of natural environments for many animal and plant species of various open habitats, such as meadows. The open, regularly scythed areas of roadsides constitute potentially suitable habitats for species of grasslands and biotopes of traditional agriculture. Threatened species, such as many plant and butterfly species from sun-scorched environments, are also commonly found at roadsides and railroad areas. This feature can be supported by good design and implementation. The preservation of biodiversity is also safeguarded and promoted in traffic environments through maintenance activities and their timing. Examples of this are the timing of roadside scything work and mowing restrictions. Traffic-allocated environments are also key areas for the control of invasive species (Väylävirasto 2022).

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3.3 Biodiversity footprints of households

Individuals and individual households influence biodiversity in their various roles. In the role of consumers, they select commodities, as owners and managers of land and natural resources they directly affect the supply of biodiversity, and in addition they act as an activists or volunteer workers, as well as citizens participating in land use and biodiversity policy (Ch 6.9). Individuals are being provided with increasing opportunities and information to make everyday consumption and land management decisions that are more in line with ecological sustainability, and they have a wide solution portfolio to mitigate BD impacts in their everyday lives. According to Dasgupta (p. 4), "we are all asset managers pretty much all the time." We manage the assets to which we have access in line with our motivations. In the following, we go beyond the consumption decisions and also describe how Finns participate in their different roles as asset managers in biodiversity decisions.

Wilting et al. (2021) reported that Finnish households are responsible for over 80% of the national consumption-based biodiversity footprint, and about half of the footprint comes from agriculture and the food industry. Therefore, especially in food choices, individual consumers and households can take biodiversity into account as one quality attribute of food products. A few studies have identified a segment of consumers who show interest in buying products with a "biodiversity label". For example, the value of genetic diversity was observed in the intention to buy Finncattle, one of the native Finnish cattle breeds, meat. This meat has potential in specialty markets, as almost a quarter (24%) of Finns would be willing to pay more for it than for conventional meat from the main breeds, with the average willingness to pay (WTP) being 26% higher than for conventional meat products (Tienhaara 2020). In a study on ecosystem-based agricultural practices that utilize ecosystem processes and aim to either reduce the negative externalities of agricultural production or increase the production of ecosystem services other than food provision, considerable consumer interest in buying and paying for this type of food was identified. The most preferred practices were more efficient use of livestock manure, the use of nitrogen-fixing crops, biological pest control and the addition of soil carbon. Having these practices as attributes of food products increased the interest in buying these products in 43% of consumers. Their median WTP was 20% higher than for conventional products (Pouta et al. 2021).

Apart from being consumers, households own natural assets and manage them. In Finland, there are over 600,000 family forest owners, who own 60% of the forest land. Their share of forest growth is approximately 70% and they supply approximately 80% of the timber utilized by the Finnish forest industry. Private forest owners conduct approximately 100,000 timber sales annually. Both in timber sales and in management actions to improve forest growth, biodiversity can be taken into account in forest owners' decisions. Husa & Kosenius (2021) demonstrated that older forest owners are less willing to adopt forest management that increases the amount of deadwood in their forest lot (i.e., leaving deadwood at harvest, allowing wind-felled trees to decay, leaving harvest residues in the forest and extending the rotation period). A higher level of education associates with increasing willingness to adopt forest management practices that increase the amount of deadwood in forests, such as through retention of deadwood and wind-felled trees. Koskela & Karppinen (2021) classified Finnish private forest owners into five types. Conservationists (9% of forest owners) support all types of conservation measures, including those without compensation. About half of them had previous experience of voluntarily implementing measures to safeguard forest biodiversity. Moderate conservationists (16%) were to some degree in favour of all the conservation measures. Compensation-oriented owners (20%) were interested in implementing the conservation measures that included compensation, both fixed-term and permanent options. Promoters of biodiversity through forest management (20%) shared a willingness to try to safeguard and enhance biodiversity as part of forest management practices by specifically taking natural values into account or leaving ecologically valuable sites outside forestry activities. The owners in the uninterested group (36%) did not express willingness to implement the presented measures in their own forests.

According to a survey by VABARO (2021), 14% of Finnish households own agricultural land. Of these owners, approximately half do not cultivate the fields themselves, but they rent the fields to active farmers. Half of Finnish agricultural landowners considered enhancing biodiversity as an important objective for their land ownership (Myyrä et al. 2008). Even though they would not cultivate the fields themselves, they have an opportunity to enhance biodiversity or other environmental objectives in rental agreements.

Households can also enhance biodiversity supply in urban environments and rural housing areas. Owners of one-dwelling and two-dwelling houses (1,058,357) and terraced houses (376,837) can use their time and money to develop their gardens to be suitable for many natural species. Annually, 602 million euros are used for garden plants and 126 million euros for other garden products (Stat.fi 2021 Household final expenditure). These expenditures are growing at an annual rate of 6%. The objective of gardening activities could be shifted little by little from aesthetics and harvest towards biodiversity. In addition, the yards of blocks of flats yards provide a place for collective biodiversity enrichment.

Natural conditions to work for biodiversity are even better for vacation homes. A typical Finnish summer cottage is located on a half-hectare lot on the shore of a lake or in the inner archipelago. The number of species depends on the soil and the variability of the environment, and also on the location. According to expert estimates, the number of species in half a hectare can vary from about 1,000 to 8,000 species, while more than 41,000 species are known to live in Finland (Vasamies 2021). Therefore, the approximately 500,000 cottage plots are important for maintaining the variety of species. The owner of a cottage has an opportunity to influence the species living on the plot. Typical examples include favouring pollinators through vegetation, insect hotels, birdhouses and rotting trees.

For individual households, several of these choices in their biodiversity portfolio cost very little. Available information and knowledge may create stewardship towards nature, motivation for conservation and lead to action that takes place without compensation requests.

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3.4 Biodiversity impacts of the public sector

The public sector is responsible for the policy actions to limit biodiversity loss and secure species and ecosystems. Several policy actions have been implemented, e.g., in environmental, agricultural and forest policies (Ch 3.2.1 and 3.2.3). Apart from these, biodiversity is impacted by economic policies. The Strategy on Climate and Nature by the Finnish Ministry of Finance recommends measures and solutions for halting biodiversity loss that integrate externalities in the market economy and promote the efficient use of resources and are cost-effective and fair. The Ministry also recommends measures that may be chosen based on the benefits gained compared with the inputs made, prioritizing measures with the most significant impact per invested euro or other unit of input. Immediate actions are recommended, even though the effects will only be perceived after a few generations. The costs of delaying action are also greater, as this will allow the environmental crisis to increase in scale (Ministry of Finance 2022).

Government ***consumption*** is responsible for approximately 9.7% of the national consumption-based biodiversity footprint (Wilting et al. 2021). In EU countries, non-market services, which have a relatively small biodiversity footprint, account for more than 90% of government consumption. In Finland, the public sector procures around 300 million euros of food (Kortesoja et al. 2022). In public procurement, the means to reduce the biodiversity footprint are the same as in the private sector. Increasing the relative consumption of plant-based foods and preferring organic food and sustainably produced meat and fish promotes biodiversity. The transparency of supply chains, expressed with certifications, also helps in public sector procurement. Encouraging examples, such as the choice of vegetables and fish in the food served by the city of Helsinki, may help others to change their practices.

Some public sector organizations have started to pilot and test biodiversity footprints. For example, biodiversity footprints have been estimated for the University of Jyväskylä (Vainio 2021).

Beyond reducing consumption-based biodiversity footprints, the public sector also has considerable opportunities to ***supply*** more diverse nature. Municipalities are in a key role. In their areas they

- map habitats
- plan land use by considering biodiversity
- remove harmful alien species
- implement nature conservation projects on land and in water areas
- take biodiversity into consideration in green area and forest management
- apply nature-based solutions that have a biodiversity handprint
- provide recreation and nature tourism opportunities
- increase citizen awareness of biodiversity

In Finnish municipalities, on average €62/inhabitant are used for the maintenance of parks and public areas (Kuntaliitto 2022a). Built parks and green areas offer a one-sided habitat for both humans and other species. Favouring diverse green areas in terms of vegetation in many cases reduces the management costs considerably (Partanen 2012). Involving citizens in the creation and improvement of urban green environments is one way to increase understanding of biodiversity and at the same time provide opportunities to commit to maintaining diverse urban nature (Ch 6.9 and 6.10). Almost every municipality (98%) is a forest owner, and 125 municipalities own more than 1,000 hectares of forest. Most forests administered by municipalities are used for commercial (51%) or recreational (42%) purposes and managed accordingly, while the proportion of protected forests is approximately 7%, i.e., lower than the national average for forests (Kuntaliitto 2022b). It is possible to increase the proportion of the area that is managed by emphasizing conservation objectives, by establishing new strictly protected areas and by increasing conservation measures, such as permanent retention of living and dead trees, in recreational and commercial forests. The financial opportunities of municipalities to increase the levels of conservation vary, but they have opportunities to obtain subsidies to improve habitats through, for example, the Helmi habitats programme. The network of so-called nature municipalities (Luontokunnat 2022) provides expertise and peer support.

Commercial state forests are managed by Metsähallitus, with the total amount being about 3.5 million hectares. These forests are multi-use where, in addition to timber production, hunting, hiking, berry picking, tourism services and reindeer husbandry are supported. In addition to the state-owned areas dedicated to nature conservation and hiking (4.5 million hectares of land and water areas), Metsähallitus aims at supporting biodiversity in commercial forests through the use of several measures. The revenue requirement for commercial forests is set politically, and at present it exceeds 100 million euros annually (Metsähallitus 2022). In the ownership-policy guidelines of Metsähallitus, the key goals are carbon neutrality by 2035, halting the deterioration of biodiversity and practicing economically, ecologically and socially sustainable forestry (VN 2021). About 0.6 million hectares of commercial forests are under restricted forest use, either completely beyond logging or under limited logging. In commercial forests, valuable nature sites are excluded from logging, dead wood is not intentionally harvested, and the number of retention trees is increased (Kaukonen et al. 2022). If politically supported, state forests offer one way to increase the area of conserved forest (Ch 6.1).

Parishes in the Evangelical Lutheran Church of Finland own 160,000 hectares of forest (EVL 2022a). The Church Council has been active in promoting carbon sequestration in forests owned by parishes (Hilasvuori et al. 2021). The biodiversity objectives are covered with the tool of an environmental diploma (EVL 2022b), which helps the parishes step by step to develop their activities, including forest management, in an environmentally friendly direction. Management practices included in the toolbox include, for example, the conservation of habitats, protection of species, and restoration of peatlands and forests.

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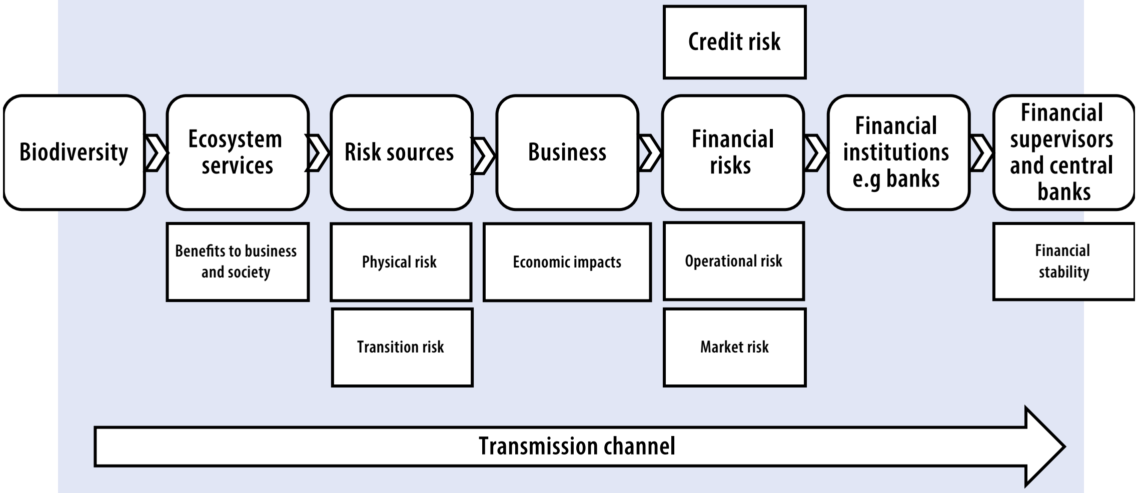
4 Biodiversity dependency in the Finnish economy

The structures, processes and functions of an ecosystem are the basis for the production of a variety of ecosystem services. Biodiversity, as a characteristic of ecosystems, can be critical for ecosystem functions and the formation of services. It can have a significant impact on the stability of ecosystems and the productivity of services. In many cases, it is not well known how changes in biodiversity will impact on the formation of ecosystem services. Here, we collect some examples of the services for which biodiversity is known to have importance and that are essential for the Finnish economy or for the well-being of Finns.

Biodiversity and ecosystem services-associated financial risks for Finnish credit institutions (Jenni Katajarinne)

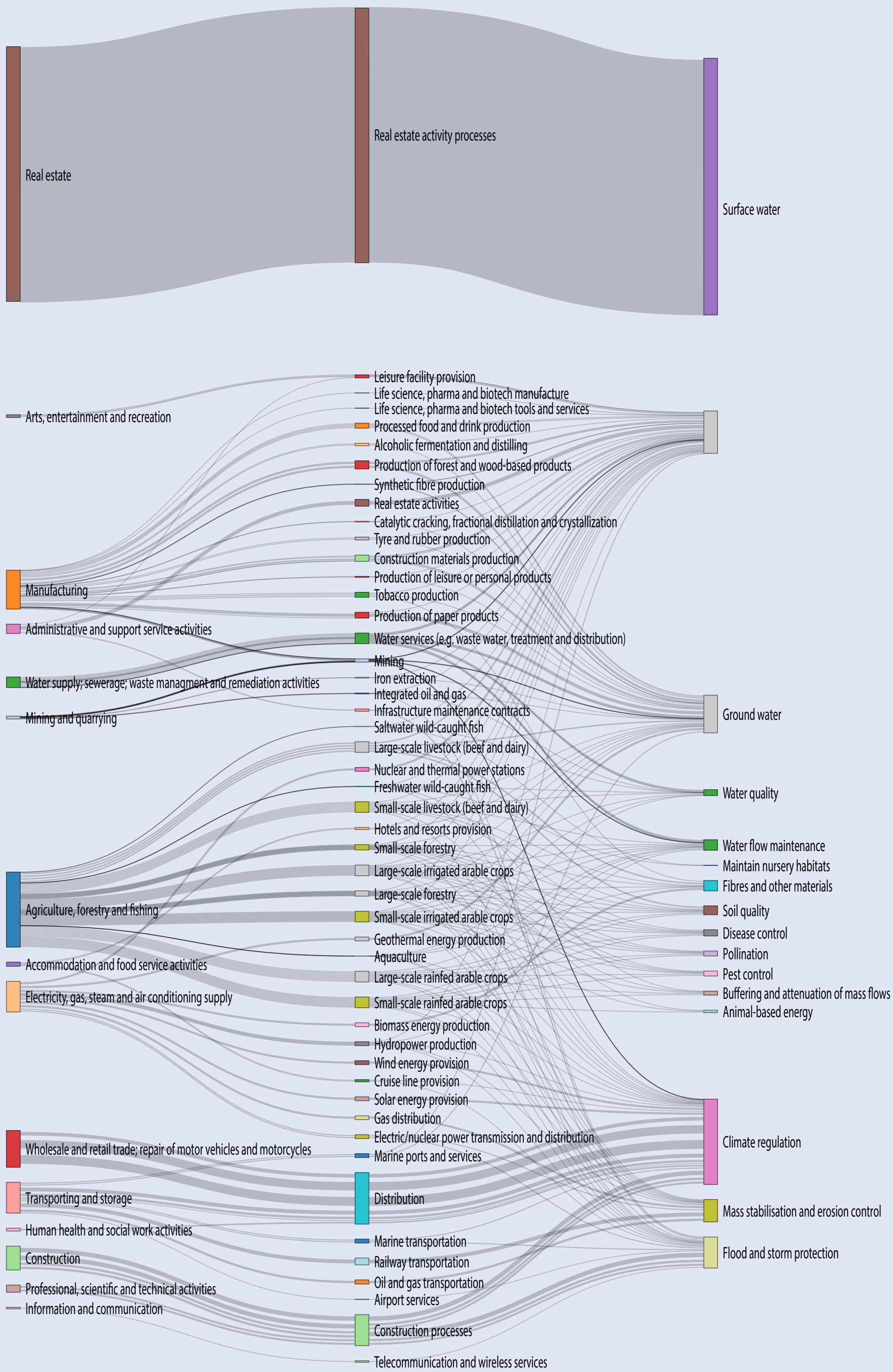
Biodiversity loss and ecosystem service degradation and the related economic costs are increasingly recognized as sources of financial risks. The risks are arising through physical (disruptions to business inputs, operating environments, or consumer demand resulting from biodiversity loss) and transition (economic losses stemming from actions taken to mitigate biodiversity loss) sources of risks caused by dependencies and impacts upon biodiversity and ecosystem services. It has become increasingly important for individual financial institutions as well as central banks and financial supervisors to better understand and manage these risks (Figure 3). However, biodiversity loss is associated with unique complexity and uncertainty, making it a challenging task.

Figure 3. Analytical framework to explore biodiversity-related financial risks by Katajarinne (2022) based on NGFS-INSPIRE (2022), Svartzman et al. (2021).



Katajarinne (2022) investigated the linkages between biodiversity loss and financial stability in Finland. This was done by assessing the financial exposure of Finnish credit institutions to sectors dependent on ecosystem services for their production processes. A quantitative analysis was done to combine loan data obtained from the Bank of Finland and ecosystem service data obtained from the ENCORE database. The results demonstrated that 23% of loans provided by Finnish credit institutions are exposed to high or very high financial risks related to biodiversity and ecosystem services. Figure 4 illustrates high and very high dependencies upon ecosystem service functioning. It shows that real estate is associated with by far highest dependencies upon ecosystem services, while agriculture, forestry and fishing are associated with the second highest dependencies. The ecosystem services linked with the highest dependencies are surface water, particularly important for estates, and climate regulation. Agriculture forestry and fishing are highly or very highly dependent on as many as 15 different ecosystem services. The findings represent a first step towards assessing the exposure of the Finnish financial system to biodiversity-related financial risks. In order to complete a comprehensive biodiversity-related financial risk assessment, further research is needed.

Figure 4. The connection between the banks' credit to various sectors and to the associated business processes and the high or very high dependency on different ecosystem services



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4.1 Biodiversity in water ecosystems and fisheries

In 2021, the value of the commercial fisheries catch in Finland was 28 million euros in marine areas and 15.4 million euros in freshwater areas (OSF 2022a, OSF 2021). In 2020, 1.5 million Finns identified themselves as recreational fishers, or over a quarter of our population. The value of recreational fisheries is more difficult to estimate. Monetizing the catches similarly as with commercial fisheries, in 2018, the value of the recreational fish catch was about 63 million euros and that of the crayfish catch 5.6 million euros (OSF 2022b). Using the travel cost method, Pellikka et al. (2021) estimated the annual total value of recreational fisheries to be 528 million euros. This estimate only takes into account those having to pay the Fisheries Management Fee and is thus likely to be an underestimate.

The economic value and viability of fisheries directly depends on the existing stocks and population dynamics of commercially and recreationally valuable fish species. Fish themselves are part of complex food webs spanning from primary producers to apex predators. Fisheries are therefore directly dependent on the entire aquatic food web, that is, biodiversity. Weakening biodiversity decreases the viability of commercial and recreational fisheries.

We directly influence food webs and fisheries by damaging the habitats and spawning grounds through, for instance, extracting sea sand, building in coastal and off-shore areas, marine traffic and dredging. We indirectly influence food webs by increasing the loading of nutrients, sediments and organic matter to water bodies. Elevated nutrient loading increases the absolute amount of algal growth, but also alters the relative quantities of algal species, thereby affecting zooplankton communities and the relative shares of fish populations (Gilbret et al. 2010, Bonsdorff et al. 1997). Sediment loading may weaken the benthic flora and reduce the winter survival of eggs of autumn-spawning coregonid fish (Jensen et al. 2009).

Organic matter increases the chemical consumption of oxygen, thereby deteriorating the conditions for many aquatic organisms (Karim et al. 2002). This, together with eutrophication and elevated water temperatures due to climate change, changes the composition of the food web and thereby the relative abundance of various sources of food for fish. Such changes have contributed, for instance, to poor condition of certain size classes of Baltic herring, particularly in the Bothnian Sea. Herring in the size class most suitable for human consumption, >12 cm, are suffering from outright malnutrition (Luke 2021). Elevated loads of organic carbon cause the brownification of lakes and rivers. This may increase the accumulation of methyl mercury in the food web and decrease the value of fish in human nutrition (Rask et al. 2021).

Climate change is causing changes in temperature and rainfall patterns, favouring certain fish species over others. Generally, eutrophication favours cyprinid fish with a lower commercial value (Ådjers et al. 2006). Their demand as human food and therefore their economic value is low, although their commercial utilization has increased in recent years. In the Baltic Sea, the main planktivore, the Baltic herring, has suffered from warming waters, and the population of sprat, a southern planktivore, is increasing. When sprat becomes the main food fish of salmon, the risk of M74 syndrome causing mortality of salmon embryos increases (Keinänen et al. 2012). Such changes decrease the economic value of fisheries.

Relative changes between populations and between size classes of certain species influence the economic performance of fisheries. Fishing tends to focus on species with the highest ratio of market value to harvesting cost, bringing their populations to lower levels. Such changes can increase the population of antagonistic fish species. It is not fully understood what has caused the rapid increase in the biomass of three-spined stickleback and whether the change is permanent. It is clear, however, that stickleback and perch are antagonistic, and that the biomass of stickleback in the Baltic Sea has increased by an order of magnitude (Olin et al. 2022). In Sweden, the abundance of perch has collapsed in many regions where stickleback populations have soared (Bergström et al. 2015).

Fishing also tends to focus on the largest individuals. Gradually, this changes the characteristics of the population by favouring individuals that spawn at a younger age. Such genetic alteration has gradually decreased the size of the pike-perch population in the Archipelago Sea (Kokkonen et al. 2015), decreasing the value of the catch.

As discussed in the section 3.2.2, the damming of rivers has led to a collapse in the stocks of some of our most valuable fish, such as salmon, trout, eel and river lamprey.

We know that fishers value certain fish species over others, with salmonoid species being particularly valued. Parkkila (2005) estimated that anglers in the Simojoki river would be willing to pay around 50 euros extra per fishing season if the salmon catch was doubled (the average catch being around 0.3 salmon per angler). These are, however, marginal values based on anglers' experiences of today's salmon populations and catches. It is difficult to estimate the value of the past massive biodiversity losses that have caused salmon catches to plummet and have all but closed the fisheries of wild trout. The annual salmon catch of the Kemijoki river alone is estimated to have surpasses 300 tons in the 19th century, compared to our entire salmon catch from all Baltic sea areas in 2021, which was 181 tons (Alaniska 2013, Luke stats). Most of the fisheries were for subsistence and were thus not recorded. Recreational fisheries and fishing tourism as we understand them today started to develop in the 19th century (Ronkainen and Särömaa 1998). A commercial booklet promoting fishing in Finland for foreign tourists in the 1930s provides a view of a land of almost unmatched fishing opportunities (Brofelt 1935, see also Suomen Kuvalehti 1929). Marttila et al (2014) estimated the lost biological potential of the major rivers by using the production of salmon juvenile in the free-flowing river Tornio as a reference point, and by combining it with results from selected restored spawning sites in constructed rivers. However, even with estimates of lost juvenile and smolt production, it is still difficult to estimate the potential economic value of restoring the lost habitats and fish populations in today's economic environment.

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4.2 Ecosystem services in agriculture

Pollination is an ecosystem service affecting all biological growth-dependent economic activities, such as the production of fibre, biofuels, wood and pharmaceuticals. Agriculture particularly relies on wind and/or animal pollination.

The vast majority of pollinators are wild animals, mainly insects, but also birds, bats and other vertebrates. There are no global data for wild pollinators, but local data indicate heavy declines in the analysed regions. In Europe, for instance, 37% of bee and 31% of butterfly populations are declining (IPBES 2016).

Heliölä et al. (2022) provided a comprehensive assessment of the development of pollinator populations in Finland. There are no development trends common to all groups and species. Within all pollinator groups there are species that are increasing, declining and remaining the same. However, within their observation period from 1980–2019, they observed some overall adaptations to climate change, as well as to the decline in open landscapes and in the habitats they provide. An interesting detail is a slight increase in the amount of young deadwood in forests, benefitting, for instance, some species of hoverfly whose larvae feed on deadwood.

Here, too, the impact is mainly found outside our borders. Trends within Finland thus do not point to a general decline in pollinators and the ensuing economic impacts on pollinator-dependent industries. However, we import food and feedstuff and will be affected by negative impacts on the development of pollination in those countries exporting to Finland, but also by the global impacts via world markets.

According to Kleijn et al. (2007), approximately 75% of global food crops depend on pollination. Their contribution to the global crop production volume is about 35%. IPBES (2016) estimated that 5–8% of the global crop production volume is directly dependent on animal pollination. By direct calculation, they would thus contribute to generating crop production with a value between $235 and $577 billion (and the same in euros). It should also be noted that subsistence agriculture in developing countries is equally dependent on pollination, even though it does not show up in sales statistics.

There have also been other estimates on regional and global levels. Gallai et al. (2009) estimated the global value of pollinating insects to be $153 billion, while Southwick and Southwick (1992) quantified the value of pollinating services in the US to range between $1.6 billion and $5.7 billion.

In Finland, the most important field crops depending on insect pollination are rapeseed, caraway, horse bean, buckwheat, linseed and red clover. Red clover is used as part of a mix for grass, and rapeseed is cultivated on about 1.5% of agricultural land; while the cultivated areas for caraway, horse bean and buckwheat are smaller. For agricultural produce, the most important ones are apples, strawberries, raspberries, currents, blueberries, zucchinis and cucumbers. Heliölä et al. (2022) estimated that between 2000 and 2021, the value of pollination for produce has varied between 25 and 39 million euros, and for field crops between 8 and 37 million euros. The strong variation of the latter is driven by annual changes in the cultivated area of rapeseed.

Since agricultural practices shifted from slash and burn to agriculture carried out in fixed locations, the maintenance of soil fertility has been the key to agricultural productivity (Hopkins 1910). This should not be understood as merely providing crops with nutrients necessary for crop growth, but also as maintaining the range of functional services provided by agricultural soils. These broadly fall into four categories: provisional, supporting, regulating and cultural services. Soil biodiversity plays a role in each of these. Soil biodiversity is comprised of the existence and interlinkages of species, ranging from extremely small bacteria and fungi to larger animals such as earthworms and moles. Maintaining or losing soil biodiversity has direct consequences for our economic performance by promoting or hampering food production. However, quantitative estimates of the effects are scarce.

By provisioning services, we mean the functional role that agricultural soils play in providing us with food, fibre and biofuels. Current agricultural practices broadly rely on the use of chemical pesticides, mechanical cultivation practices and external nutrient inputs instead of soil ecosystem services that could, to some extent, provide similar effects. For instance, soil microorganisms play a major role in producing essential ecosystem services, such as the regulation of the climate, nutrient cycling, plant growth promotion and abiotic stress tolerance, controlling pests and diseases, as well as in the degradation of toxins and pollutants (reviewed by Hartman and Six 2022). In addition, fungi are important in phosphorus and water uptake, in carbon sequestration, in maintaining a good soil structure and in disease control, preventing further degradation of soils (Hannula and Morriën 2022, Frąc et al. 2018). However, soils enriched with high phosphorus fertilization allow crops to take up phosphorus from the soil solution, soils can be tilled and limed to improve soil structure, various pesticides can be applied to keep the crop pests at bay and irrigation may be used to promote water uptake. The substitution effect has also been confirmed for N fertilizers and farming practices increasing crop diversity and organic matter: For low N fertilization levels, these practices increase crop yields, but the effect disappears for high N fertilization levels (McLaren et al. 2022). Therefore, it is difficult to assess the quantitative value of such offset provisional services, as they could be associated with lower or higher and more certain or uncertain levels of food production.

Supporting services include the formation and maintenance of soil organic matter and soil structure. Regulating services particularly refer to the hydrological properties of soil, and most importantly to soil's capacity to absorb and hold water. Soil biodiversity plays a role in both supporting and regulating services. The circulation of organic carbon, for instance, relies on soil biota in all its stages, from fragmenting and burying the soil residues to the eventual decomposition of the organic matter. Cultural services are somewhat ambiguous. In economic terms, they could be broadly referred to as providers of the option value of soil as natural capital, of which biodiversity is a crucial part.

Soil biodiversity thus is a crucial component of the functional services provided by the soil. In addition, farming practices with less soil tillage and less input use are associated with a higher soil microbial biomass and higher microbial carbon content (Whalen and Sampedro 2010, D'Hose et al. 2018). Peltoniemi et al. (2021) demonstrated that this also holds true for Finnish arable soils: organic farming systems had a higher microbial activity and biomass and microbial richness. This implies better soil health associated with organic farming. However, it is difficult to obtain economic estimates of these ecosystem services.

One way to obtain such estimates would be to compare the economic performance of the more sustainable agricultural systems with conventional farming. Van der Ploeg et al (2019) conducted such a comparison, stating that the economic potential of agroecological farming systems is substantial. Their results hinge on the assumptions of higher prices obtained from agroecological systems and lower costs of input use. Reganold and Wachter (2016) pointed out that price premiums needed for organic farming to match the profitability of conventional agriculture are fairly low, between 5% and 7%. Actual premiums are higher than this. Organic farming is thus likely to keep expanding as long as the premiums do not fall below the threshold level. Agroecological farming systems tend to have higher labour costs, which should elevate the production costs (Crowder and Reganold 2015). On the other hand, more labour means more employment opportunities in rural areas, which is often viewed as desirable. Bhardwaj et al. (2011) altered management practices in intensively cultivated regions in the US Midwest and concluded that less fertilizer use and tillage would improve soil quality while maintaining crop yields.

Following the precautionary principle, we should avoid farming practices that damage soil biodiversity. It appears that there is a yield gap in farming systems based on agroecology, and that it might nevertheless be possible to obtain economically better profits for farms. However, it seems to be very difficult to provide monetary values for the ecosystem services provided by soil biodiversity.

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4.3 Forest sector

In Finland, like elsewhere in the world, economic activity is dependent on healthy and well-functioning ecosystems. In the long term, biodiversity loss will deteriorate this basis. From the viewpoint of the forest sector, key issues are whether biodiversity can affect forest productivity and what are the impacts of biodiversity on ecosystem resilience. In addition to productivity, resilience is also important from the point of view of economic sustainability, as natural disturbances (e.g., forest fires, storms, pest insect outbreaks, fungal infestations) might affect forest growth and wood quality and cause significant economic losses.

Dasgupta (2021) summarised a large body of work demonstrating that the number of functional groups of species in an ecosystem is strongly related to ecosystem productivity. Functional diversity points to complementarities among traits. Mutual dependence among species is a reason why biodiversity enhances ecosystem productivity (Dasgupta 2021), but another (not mutually exclusive) explanation, at least locally, may be resource partitioning due to differences in species' ecological niches (i.e., different requirements for space, light and nutrients). Paquette and Messier (2011) found that, in temperate and boreal forests of Canada, there was a strong and positive link between the functional diversity of tree species and tree productivity (as measured on annual growth increment). This relationship appeared stronger in the boreal than in the temperate zone. Likewise, Man and Lieffers (1999) examined tree growth in pure and mixed trembling aspen (*Populus tremuloides*) and white spruce (*Picea glauca*) stands in boreal Alberta, Canada, and found that, after controlling for stand age, annual diameter growth was larger in mixed stands. These two analyses and interpretations are strongly supported by meta-analyses of data from mono- and polyculture plantation forests: trees indeed usually grow better in mixed than in single-species stands (e.g., Kelty 2006, Piotto 2008, Zhang et al. 2012). However, Zhang et al. (2017) also demonstrated that, while this general pattern concerns different vegetation layers in forests, and understory richness is positively linked with overstory richness, overstory biomass can be negatively associated with the biomass production of understory layers, perhaps due to competition for resources.

A global analysis by Liang et al. (2016) provided strong evidence that the productivity of forests would decrease at an accelerating rate with the loss of tree species diversity. According to these authors, this decline varies among regions, but it may be relatively (proportionally) largest in North-Eastern Europe and some other global regions. Authors also highlighted the potential benefits of a transition from monocultures to mixed tree-species stands in forest management. Data by these authors contained repeated tree measurements from a total of 777,126 paired sample plots placed in mono- and polyculture plantations, distributed across 44 countries and 13 ecoregions.

The issue of negative or positive effects of tree-species mixtures on tree growth and ecosystem functioning is, however, controversial (Liu et al. 2018). Impacts on forest growth and yield depend, for instance, on the tree species mixture, stand structure and tree age (Huuskonen et al. 2021). According to Huuskonen et al. (2021), in Fennoscandia, mixed forests appear to provide a higher output of most ecosystem goods and services, including higher biodiversity and improved risk management, soil properties and multiple-use values. However, as at least in the Nordic countries most of the infrequent broadleaved tree species currently have low economic value, and the retention of these trees will bring about costs in the form of reduced production opportunities.

According to Liang et al. (2016), a decrease in biodiversity would also impact, for example, the forest carbon absorption rate, and it might thus compromise the global forest carbon sink. This is in line with the above-described positive effect of tree-species diversity on tree growth: better growth means more absorbed carbon. However, the relationship between components of biodiversity other than trees and carbon absorption is currently inadequately understood, although the richness of many species groups correlates positively with many ecosystem services, including carbon storage (e.g., Balvanera et al. 2006, Brockerhoff et al. 2017).

Another benefit of biodiversity is an increase in resilience. Ecosystems are subject to shocks and disturbances, such as pests, drought, storms or other environmental changes, which are likely to increase as a consequence of climate change. Brockerhoff et al. (2017) argued that as disturbances are predicted to increase in frequency and intensity, declines in biodiversity are likely to reduce the resistance of forests against climate extremes and other disturbance factors (e.g., Jactel et al. 2017). Resilience towards different kinds of disturbances is important for the forest sector from an economic perspective, as it reduces, for instance, the risk of sudden changes in wood availability and in wood costs. Examples from British Columbia in Canada and Central Europe demonstrate how large-scale pest invasions might have significant impacts on the forest industry (e.g., Corbett et al. 2016, Hlásny et al. 2021).

At a certain level, diversity in a resource base can be seen as an insurance against changes in the operational environment, as industrial demand and technical readiness are constantly changing. Consequently, the need for different types and amounts of raw materials will also change. In other words, many decisions in forest management, including planting and seeding, are usually based on current conditions and industrial demands, whereas with alterations in climate, conditions might within just a few decades become unfavourable for currently popular "industrial" tree species, notably Norway spruce (*Picea abies*) (e.g., Venäläinen et al. 2020).

Despite increasing knowledge of the impacts of biodiversity on ecosystem functions, resilience and productivity, there is still much we do not know about the ecological and economic impacts of biodiversity loss on the forest sector. For example, microbes comprise a large portion of life's genetic diversity, but despite their abundance, the impact of soil microbes on ecosystem processes and tree growth remains poorly understood (van der Heijden et al. 2008). At the general level, Anthony et al. (2022) found the species community composition (beta diversity) of ectomycorrhizal fungi to predict the tree growth rate across Europe, while fungal richness and diversity were not significantly correlated with tree growth. Our understanding of the mechanisms behind this relationship is often only tentative, and further research is needed.

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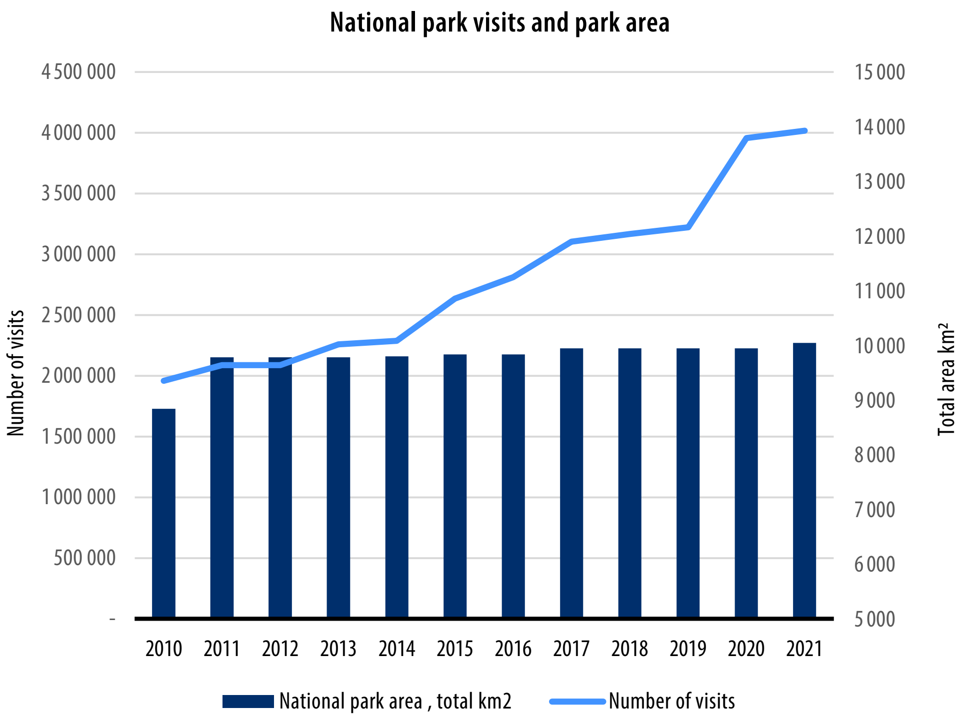
4.4 Recreation and tourism

Outdoor activities in nature are an essential part of the Finnish way of life (Neuvonen et al. 2022). As many as 96% of adult Finns enjoy outdoor activities, engaging in them on average 3 times a week and 182 times a year. Most recreational visits take place in nature close to home. About 30% of close-to-home recreational trips occur within 300 metres of the home and about 85% are within 10 kilometres of the home. For outdoor recreation, in particular, the diversity of habitats has importance.

Nature experiences are key motivating factors for outdoor activities in about 66% of recreational visits. Most studies concerning biodiversity and recreation have focused on national parks. Typically, national parks are established in areas that are characterized by diverse or otherwise significant natural features that are considered valuable at the national or international level. According to some observations (Fredman et al. 2007) the mere designation of a place as a 'national park' automatically makes it more attractive to visitors. Visits to a national park describe the importance of biodiversity for recreation. According to a survey by Neuvonen et al. (2022), approximately 40% of Finns visited a national park during a year, and national parks were visited a little over 4 million times a year. National park visits (Figure 5) had increased by 2% compared to 2020, but by as much as 25% compared to 2019 due to the coronavirus pandemic. The traditional reasons for visiting a national park are nature experiences and the purity of nature, the scenery and the effect of the visit on well-being.

Figure 5. Number of recreation visits to national parks and park area. Sources: https://www.metsa.fi/vapaa-aika-luonnossa/kayntimaarat/kayntimaarien-kehitys/ https://www.metsa.fi/maat-ja-vedet/suojelualueet/suojelualueiden-pinta-alat/.



Neuvonen et al. (2010) demonstrated that the number of biotopes in a national park had a significant and positive influence on the number of visits to national parks in Finland. However, the effect was weaker than the effect of the supply of opportunities for recreational activities. The results imply the dual role of national parks: their outstanding natural characteristics enable nature experiences, but activity-oriented parks also fulfil recreational needs in the most populated parts of the country. A study by Puustinen et al. (2009) indicated that the number of visits was associated with the main nature type, implying a continuum from the highest numbers of visits to mountainous (i.e., fell) parks, the second highest to forest and water-based parks and the lowest number of visits to mire parks. A positive effect of a high diversity of species on recreational visits has also been observed concerning Baltic Sea recreation on the Finnish coast (Bertram et al. 2019).

Lyon et al. (2011) revealed the importance of biodiversity hot spots as nature attractions. Their results from the Oulanka National Park in northern Finland demonstrated the attraction of biodiversity for visitors, but also the difficulty in the coexistence of recreation and conservation, as the important habitats for endangered species are often located in or close to zones of high visitor use. According to a review by Tolvanen & Kangas (2016), the most sensitive plants, birds and mammals decline or disappear from disturbed sites, and the species composition shifts from 'wild' species to cultural and human-associated species.

For foreign visitors, who comprise 7% of national park visitors, the importance of biodiversity at a destination has been less studied. However, the importance of nature in general is documented in the number of overnight stays, amounting to 1.8 million in Lapland and 1.1 million in the Finnish lake district (Business Finland 2022).

The Nature Services of Metsähallitus use visitor tracking data to calculate the local economic impacts of the use of money by national park visitors. The results indicate that the state's investment in the recreational use of national parks and hiking areas is returned to society in the form of strengthening business and employment. The impact of the use of money by visitors to national parks on the local economy was estimated at EUR 310.3 million, the employment impact was 2,452 person-years and the growth from 2020 was 21%. The impact was found to be greater in tourist areas with longer stays and more services. The impact of visitor spending on the local economy grew faster than the number of visits (2020–2021) (Konu et al. 2021).

Landscape preference studies have demonstrated that both Finnish people and foreign visitors like relatively old forest with relatively thick trunks (Silvennoinen 2017). However, foreign visitors did not value old growth forest with decaying wood. To avoid low acceptance, the extensive visible presence of deadwood, e.g., 20 m^3/ha, would necessitate effective communication of the ecological benefits to residents, particularly in urban areas (Korhonen 2022: Gundersen et al., 2017).

The effects of different ecosystem and landscape characteristics on the monetary value of recreation in Finland were summarized by Lankia (2015). The monetary value can be measured either with stated preference methods or with revealed preference methods such as the travel cost method (e.g., Lankia 2020). The monetary value of recreational services could be increased by increasing the level of biodiversity (Tyrväinen et al. 2014, Juutinen et al. 2011, Lankia et al. 2014, Horne et al. 2005). According to Tyrväinen et al. (2014), visitors to Ruka-Kuusamo were willing to pay €12.27 more per one-week visit for an improvement in landscape quality so that there would be no visible traces of intensive forestry operations, and €10.82 more for a slight improvement. They would claim compensation of €36.83 per one-week stay for a decrease in biodiversity resulting in 10% of species in the area becoming extinct. In the Oulanka National Park, visitors would claim compensation of €12.20 per visit for biodiversity loss resulting in 15 species becoming extinct in the park (Juutinen et al. 2011). Furthermore, they were willing to pay

€6.73 per visit for a 10% increase in the population of endangered species in the park. However, Lankia et al. (2014) reported that Finnish outdoor recreationists found removing dead wood and decayed wood, which are crucial for forest biodiversity, almost equally often desirable as undesirable, indicating the heterogeneous preferences for biodiversity and recreation among Finns. In a study on citizens' willingness to contribute to the management of recreational quality on private lands (Lankia et al. 2014), 66.5% of the respondents found forest clear-cuts undesirable, but only 9% of them were willing to pay for the postponing of clear-cuts.

Few studies have examined the value of biodiversity for recreation in the urban environment. Among other recreation services, Mäntymaa et al. (2021) valued the restoration of a brown trout population in a city park. The number of visits would increase by 21%, also leading to a considerable increase in the total recreational value. A preference for an improvement in the trout population was shared among all the visitors (Mäntymaa et al. 2022). Clear benefits of stream restoration (Lehtoranta et al. 2012) close to the natural state have been reported, as households in the City of Helsinki had an average willingness to pay for the management and restoration of streams of approximately €8–16 per year.

The recreational benefits of freshwater biodiversity actualize in fishing activity and the possibility to catch salmon species. For example, on the Teno river, the estimated benefit of a trip for a visitor, ranges from 235 to 338 euros (Pokki et al. 2018). The number of fishing trips associates with salmon catch, underlining the importance of the proper and sustainable management of recreational salmon fisheries.

Beyond participation in outdoor recreation and nature tourism inside Finland, 20% of Finns (in age classes 15–79) annually travel to other countries for nature tourism (LVVI3 data). If they are assumed to make one nature trip per year, the annual number of trips would be 873,000. Of the 110,000 annual holiday trips (before COVID) to Finland, 59% were due to motives related to nature experiences (Visit Finland 2018). This means 65,000 nature trips to Finland. This rough calculation illustrates the negative balance in nature trips, implying the danger of outsourcing the effects of nature tourism to other countries and causing possible impacts on biodiversity there.

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4.5 Health and well-being

Biodiversity and its healthy functioning support human well-being and health. The importance of this is that the functional consequences of biodiversity matter. These functional consequences have been conceptualized in many ways. They have been called supporting and regulating ecosystem services and primary ecological values. A more direct and measurable link to health would help convey the explicit benefits of biodiversity to health and develop ways to reinforce collaborative biodiversity mainstreaming (Karesh et al. 2012; Aerts 2018; WHO 2015).

The CBD Strategic Plan for Biodiversity (2011) and its Aichi Biodiversity Target 14 refers in general terms to biodiversity and human health and well-being. According to WHO (2021, 2), "Human health is a state of physical, mental and social well-being, and not merely the absence of disease or infirmity. Health can be considered a dynamic state: it is not fixed or absolute but constantly responding to environmental, social, biological, emotional and cognitive conditions." Huber et al. (2014, 3) expanded on the original formulation of WHO (1946) and they proposed "the formulation of health as the ability to adapt and to self-manage. This could be a starting point for a similarly fresh, 21st century way of conceptualising human health with a set of dynamic features and dimensions that can be measured." However, ecosystems and non-human actors are absent in the formal definitions of health.

On the ecosystem level, the metaphor of health is not unknown. The metaphor of ecosystem health made its entry to nature policy in the late 1990s. Ecosystems are considered healthy when their structure and functioning are sufficiently stable over time, despite disturbances in species relations and fluctuations in the richness of local populations. Healthy ecosystems have a capacity to resist disturbances or to recover their typical features thereafter. Health also refers to the capacity to renew critical aspects of functioning or establish the novel patterns of interactions with the environment. A healthy ecosystem has continuity across multiple spatial and temporal scales. (Haila 1998, Gundersson and Holling, 2002). Ecosystem health is a workable metaphor, because biodiversity cannot be reduced to individual species or their interrelation. Biodiversity and health are systemic features of interconnected systems.

Out in the wild

It is important that citizens have access to nature. The urban planning of cities and the planning of everyday life on the individual level should, according to the most recent findings, provide a diverse set of entry points to nature.

There have already been a multitude of studies indicating the connection between health and biodiversity (Hartic et al. 2014). Objective and subjective health effects often intertwine when measured and perceived biodiversity are studied together (Marselle et al. 2021), and some effects are direct while others are indirect (Aerts et al. 2018). The absence of noise in nature may lead to recovery from stress (Tyrväinen et al 2018). Exposure to nature increases physical activity and mental well-being (Gianfredi et al. 2021, Methorst et al. 2021, Barton & Pretty 2010), and physical activity in forests reduces stress (Tyrväinen et al. 2018, 2014, Pasanen et al. 2014). Importantly, Simkin et al. (2020) found that the mature commercial forest and old-growth forest were significantly more restorative compared to the young commercial forest and urban recreation forest. In addition, while social contacts in nature have been much studied, a less studied phenomenon is how nature affects sociality itself. Medium diverse forests, or economically managed forests, arouse more positive emotions than more diverse or less diverse forests. However, a good ecological or natural quality of the environment is associated with positive feelings by spectators (Carrus et al., 2015).

Underneath the skin

Besides this "possibility to visit nature" aspect, there is another and even more crucial aspect to the health effects of biodiversity. People should not only have entry points to visit nature but should in a habitual manner interact with biodiversity as part of their everyday life. Haahtela (2014, 21) reasoned this as follows: "Humans have evolved with microorganisms, which may not only comprise bacteria and fungi, but also viruses and microscopic protozoans, although hardly any data on the latter are available. Human commensals are no longer considered as passive bystanders or transient passengers, but increasingly as active and essential participants in the development and maintenance of barrier function and immunologic tolerance."

The biodiversity hypothesis states that contact with natural environments enriches the human microbiome, promotes immune balance and protects people from allergies and inflammatory disorders (von Hertzen et al. 2011). There is a growing body of scientific evidence on the biodiversity hypothesis. Donovan et al. (2021), for example, tested whether exposure to plant diversity protects against childhood acute lymphoblastic leukaemia (ALL). It was found that the diversity of plants to which the child was exposed in the first two years of life protected against ALL type leukemia. Children who have lived in more biologically diverse regions less often develop childhood asthma (Rajagopala et al. 2016). Nurminen et al. (2021) found that a rural environment in the first year of life reduces the risk of diabetes, and that a heavily built environment increases the risk of autoimmune diseases such as allergies and asthma within a radius of one and a half kilometres from home. Interestingly, the length of the winter snow season has an effect. Especially importantly, a growing body of evidence indicates the significance of childhood contact with biodiversity in the prevention of various auto-immune diseases (Roslund et al. 2022; 2021, 2020; Puhakka et al. 2019).

In summary, seen from this perspective, ecosystem services are not benefits flowing from the environment to humans. Ecosystems and their services are part of human life, that is, human life is constituted and sustained by the functional consequences of biodiversity. Ecosystem services occur inside and outside the human body. This view is supported by the "One Health" approach to human and non-human health and biodiversity (Romanelli et al. 2021). It recognizes the connections between the health of humans, animals and the ecosystem. This integrated perspective helps frame and communicate biodiversity's essential contribution to the integrated and holistic understanding of health. There have been no systematic monetary studies on the economics of biodiversity's health effects in Finland or elsewhere.

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4.6 Existence values

Existence value is the value of knowing that a particular species or habitats do and will continue to exist. It is independent of any use that the valuer may make of the resource. Existence values are classified among cultural ecosystem services.

In Finland, the value of BD on its various levels and in varying biotopes has been measured with several stated preference studies (Johnston et al. 2017). Value estimates are dependent on the time of measuring them and how the scenario for increased or decreased biodiversity is defined.

Of the various levels of biodiversity, the existence value of **genetic diversity** has especially been examined regarding agricultural genetic resources. In a study by Tienhaara (2020), the value of agricultural genetic resources was measured with several stated preference methods. The estimated value for a Finnish citizen of conservation programmes to improve agricultural genetic resources in Finland, i.e., traditional breeds and varieties, was €47.90. The knowledge level of the respondent concerning native breeds and varieties has significant importance for the existence values of genetic resources as providing basic information of genetic resources doubled the value (Tienhaara et al. 2022).

Studies on the existence value of **individual species** are currently ongoing. Preliminary results on the conserved Saimaa seals have demonstrated the association of existence values with the size of the seal population, but also the dependence on values from conservation measures, such as restrictions on fishing or motorized vehicle use (Our Saimaa Seal project). For some other key species, such as the flying squirrel, research on existence values is taking place in ongoing projects.

The existence values for the third level of biodiversity, **habitats or ecosystems**, have been defined for forest ecosystems, peatlands, agricultural ecosystems, marine ecosystems and freshwater ecosystems. Several valuation studies for forest conservation were carried out in Finland around the turn of the millennium (Siikamäki 2001; Kniivilä 2002; Horne 2008). All of these studies, reviewed by Haltia (2015), analysed the issue from different methodological perspectives or included differences in the valued goods. According to the review of Haltia (2015), Finnish citizens support increased forest conservation, with 74% being prepared to pay for increased conservation and 16% supporting increased conservation but not willing to pay for it. The median WTP in the contingent valuation was €72. A recent study on citizen preferences for forest policy demonstrated that Finns are interested in a change in forest policy to prevent nature loss and increase carbon sequestration and employment (Mäntymaa et al. 2022a). From the heterogeneous citizen groups observed, a group containing 17% of respondents especially supported biodiversity conservation. In addition, Mäntymaa et al. (2022b) showed the importance of biodiversity in citizen choices of land use policy options.

Research on peatland ecosystem services has revealed the values of species diversity over values of carbon storage, water purification, berry picking opportunities or peat extraction. Willingness to pay per person for maintaining species diversity at the current level was €117/year/respondent (Saarikoski et al. 2022). However, considerable heterogeneity in values between citizen groups was observed (Grammatikopoulou et al. 2019).

Tienhaara et al. (2020) provided value estimates for the existence of traditional rural biotopes, the key hot spots for agricultural biodiversity. The estimates varied between €40–76/year/respondent. In an ongoing project (VABARO), the existence value of biodiversity in cultivated agricultural areas is being defined. A 20% change in cultivation methods towards a more diverse direction would create a value of approximately €10 per respondent annually, but a 20% decrease in diversity would cause a negative effect on existence values of approximately €100/year/respondent.

For the marine environment, Nieminen et al. (2019) reported that Finns are willing to contribute €105–123/year/respondent to achieve a good environmental status (GES) in the Finnish marine area. This indicates that the total monetary benefits of reaching a GES are €432–509 million annually. Even if they do not use the sea themselves, Finns place especially high importance on reducing the concentrations of hazardous substances and eutrophication, the existence of habitats for species, and on recreation and aesthetic values.

According to a study by Artell et al. (2022), the majority of citizens (80%) were willing to pay for a programme to restore rivers in Finland when the focus of restoration was the living conditions of migratory fishes. The average willingness to pay was €110 annually over a 10-year project period. Improvements in river biodiversity at Kemijoki have been demonstrated to have a slightly lower value than recreation values (Ruokamo et al. 2022). The willingness to pay for an improvement in the ecological state varied around €30 per year if paid in the consumer's electricity bill. An improvement in fish stocks was valued approximately equally to an improvement in the ecological state. Lehtoranta et al. (2017) reported willingness to pay estimates for an improvement in the status of 200 forest streams in the Koillismaa region. Residents had the lowest and forest entrepreneurs the highest mean willingness to pay annually per household for a five-year period, the respective amounts being approximately €15 and €25.

The existence value of an extensive conservation programme covering several habitats has been investigated in the case of the Natura 2000 programme (Pouta et al. 2000). The median willingness to pay for implementing at least a 3% increase in the current conservation level was about €33 per household as a lump sum. In addition, conservation planning methods were important for the public, as the mean WTP for the programme as a lump sum varied from €21 with the implemented planning methods to €102 with participatory planning methods.

Existence values, typically expressed with average WTPs, vary considerably between population groups (Tienhaara 2020). Tienhaara (2020) found a segment of the population with exceptionally high existence values, a segment with clear conservation preferences but moderate values, a segment that would not pay for increased conservation and supported maintaining the current state, and a segment that did not respond to the survey questions in a meaningful way. From these different population segments, the second one follows the assumptions of the economic theory of consumer preferences and is the most likely to provide reliable value estimates.

These estimates of existence values were measured at the time of each study. Nevertheless, several meta-analyses of valuation studies have shown that existence values have not changed considerably over time. There is an indication that wealth in society as a whole determines the variations in WTP (Jacobsen & Hanley 2009), and it has been estimated that the mean annual WTP for avoiding human-caused biodiversity losses ranges from 0.2 to 0.4% of GDP per capita (Nobel et al 2020).

In empirical valuation studies, it might be difficult exactly define whether only existence values are included or if the estimates also include option values, indicating the importance of the future use of biodiversity, or insurance values, implying the importance of biodiversity for the formation of ecosystem services under future conditions. Nevertheless, the summarized value information can be used to evaluate the efficiency of conservation programmes by comparing the value estimates with the costs of conservation. However, in evaluations, there is typically also a considerable amount of uncertainty in the conservation impacts of different conservation measures.

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5 Development in biodiversity and policy

Current situation

The Post-2020 Global Biodiversity Framework (Convention on Biological Diversity 2022) has ambitious targets not only for conserving biodiversity globally but also for improving the equity, social inclusion and well-being of people who depend on nature. Over the past 25 years, since the launch of the Natura 2000 reserve network, the European Union has developed a strategic approach to biodiversity protection. This has meant that biodiversity is also protected outside protected areas by sustaining the essential ecosystem structures and functions with partnership and collaboration. Being more comprehensive and longer term, the strategic approach enables co-benefits and helps to orchestrate policy measures in an effective and fair manner (European Commission 2020a).

Finland has had an ambivalent approach to biodiversity protection. As a rule-abiding member state, EU regulation, such as the Habitats Directive and Birds Directive, has been incorporated into the national legislation. However, the historical institution of land ownership and the tradition that has grown from it have made the protection of nature values a contested issue (Siiskonen 2007). The general idea that humans need ecosystems to survive is well understood, but how this translates into opportunities and responsibilities in actual resource management and governance is a different matter. There are no break-through victories in bending the curve of biodiversity loss in Finland or elsewhere in Europe and beyond (Hyvärinen et al. 2019; Mönkkönen et al. 2022; EEA 2020; Secretariat of the Convention on Biological Diversity 2020).

The total biomass of wild mammal species weighs less than one sixth of what it was before extensive human impacts, and importantly, the biomass of wild animal species is about 4% of the total, while humans and domesticated species comprise 96% of Earth's mammal biomass (Bar-on et al. 2018). There are currently more than five hundred vertebrate species on Earth for which fewer than a thousand individuals are alive, and fewer than 250 individuals are left for most of these species (Ceballos et al. 2020). An animal species is classified as endangered if its population is less than a thousand reproductive individuals, or if its population has declined by more than 30% in the previous three generations or ten years (IUCN 2022; Hyvärinen et al. 2019).

In Finland, according to the most recent species assessment of 2019 (Hyvärinen et al. 2019), the decline of biodiversity continues, and measured by the extinction index, the decline has accelerated. Of the 22,400 animal and plant species in Finland, 2,667 species were classified as endangered. The relative proportion of threatened species grew from 11% in 2010 to 12% in 2019. It was estimated in 2019 that 312 species had gone extinct, while in 2010 the estimate was 108 species. Forests harbour 31% of endangered species and agricultural areas 24%. Due to climate change, 38% of fell species were estimated to be endangered. Among rocky-habitat occupying species, the proportion was 23%. (Hyvärinen et al. 2019).

Species mostly become endangered because they lose their habitats, or their habitats become fragmented. According to an assessment of habitats in 2018 that covered some 388 habitats or habitat combinations in Finland, almost half of the habitats (186) were assessed as endangered and most of them (59%) were located in southern parts of the country (Kontula & Rainio 2019). All the traditional rural biotopes were assessed as endangered, together with 67% of forest biotopes, 58% of Baltic Sea coast biotopes and 57% of bogs and mires. Because of a serious knowledge gap regarding coastal habitats, only 70% of sea, inland and coastal habitats could be assessed.

On the European level, the situation is no better. The European Union protects 1,389 animal and plant species and 233 habitat types. Fifteen per cent of habitats have a good conservation status, while 81% have a poor (45%) or bad (36%) conservation status at the EU level. Nine per cent of habitats having an unfavourable conservation status are improving, while 36% of these habitats are deteriorating. Trends towards improvement can mainly be observed for forests, while the highest number of deteriorating trends is seen for grasslands, dune habitats and bogs, mires and fens. Over a quarter of species have currently a favourable conservation status, which is an increase of 4% higher than in compared with the previous reporting period of 2007–2012. Reptiles and vascular plants have the highest proportion with a favourable conservation status. While 6% of the species with an unfavourable conservation status are displaying a trend towards improvement, thirty five percent are following a deteriorating trend. (EEA 2020).

Strategic approach to the persistent policy challenge

Biodiversity has remained a persistent policy challenge. One reason for this is that biodiversity is not easy to operationalize. Understanding biodiversity as a distinct organizational property of nature has not proved successful in conservation practice, although, for example, the Convention on Biological Diversity (CBD 1992) has helped to routinise the tripartite definition to genetic, species and ecosystem diversity. However, after thirty years, there is still no remedy for biodiversity loss. As a consequence, the 5th Biodiversity Outlook (Secretariat… 2019) presents a multi-layered approach from genes, species, habitats, ecosystems to biomes and the biosphere, and some key international environmental communities, such as the IPCC (2019) and the CBD (2019), have shifted their focus on land use to concretize the biodiversity challenge and make the remedies more effective.

The spatial land-use-based approach has posed a question: how much land and water cover must be put aside from human use to protect biodiversity? In the Biodiversity Strategy for 2030, the European Commission (2020a) suggests that 30% of land and water cover should be protected, of which 10% should be strictly and 20% softly protected. These numbers did not come from the air. Hanski (2011) argued earlier, by drawing from the metapopulation theory and abundant empirical data, that protection measures should cover a third of the land and water cover, and that one-third of this should be legally and strictly while two thirds collaboratively and voluntarily protected. The rule of a 'third of third' does not make conservation actions any easier. However, it brings forth the idea that in order to provide and safeguard biodiversity, essential ecological structures and consequent functions, substantial set-aside areas of land and water cover or area are needed. For example, if the initial cover of old growth forest reduces to less than 10%, the extinction rate will drastically accelerate (Hanski 2015; supported also by empirical data; see Koivula et al. 2022). However, if the third-of-third rule is ensured, biodiversity is expected to take care of itself.

To operationalize biodiversity policy and support biodiversity recovery, in addition to the Biodiversity Strategy for 2030, the EU has launched a multitude of strategies, for example, the Green Deal, Bioeconomy Strategy, Climate Adaptation Strategy, Forest Strategy, Green Financing and Taxonomy, Farm to Fork Strategy, Circular Economy Action Plan, and the forthcoming Soil Strategy. The most recent strategic step, and highly debated in Finland, is the proposal for a Nature Restoration Law (European Commission 2022). The proposal states: "The lack of progress in the biodiversity strategy up to 2020 shows that voluntary commitments by the Member States are not enough to achieve the EU's objectives for restoring ecosystems." (p. 7). For this reason, the European Commission (p. 7) has called for harder measures: "Setting legally binding targets and obligations for ecosystem restoration at the EU level would bring consistency to the action needed across the EU to reach the overall objective."

At first sight, the proposed Nature Restoration Law does not seem typically strategic, i.e., voluntary and collaboration-based, but rather it appears legislative, and the European Commission seems to undermine the general strategic approach to biodiversity with it. However, the proposed regulation on nature restoration can be interpreted from within the frame of strategic biodiversity policy. While the proposal sets the European biodiversity policy bar high, it opens the meaning and significance of biodiversity loss for the public, stakeholders and decision-makers to reason and debate about.

The economics of biodiversity policy

The proposed regulation on nature restoration concretizes the general purpose and task of bending the curve of biodiversity loss, and, more strategically still, the proposal opens a public debate on the cost-effectiveness and reasonableness of the existing and yet needed conservation measures. There is room for debate and the inventions of novel conservation measures. Member states will face binding obligations, but the exact mean of fulfilling them will be left to the member states to design, decide and implement. Productive practices must be withdrawn from 10% of land and water cover and radically altered on 20%, while on the remaining 70%, the practices will be governed by the rules each member state finds appropriate and sustainable. It is easy to see that this may be hard.

The strategic approach to biodiversity protection the EU has taken is strongly supported by the economics of biodiversity promoted in the Dasgupta Review. In the Review, future biodiversity policy is presented as multilevel strategic asset and portfolio management. This strategic game is set for many players, multiple types of assets and objectives in various problematic situations where trade-offs and synergies are present. However, keeping in mind that biodiversity is not a distinct structural or institutional property of nature, but a multiscale and complex thermodynamic feature of life (Haila 2016), strategic asset management must become truly strategic.

For Freedman (2013), strategy is the art of creating power. The existing strategies, and those underway, are tools for the EU and members states to create the power to halt biodiversity loss. This calls for careful identification of actual and potential assets, interrelated agent, species and habitat-specific portfolios, and the design and implementation of adaptive management schemes directing individual and social action towards jointly defined strategic biodiversity goals. In Finland, the renewed Nature Conservation Act and the forthcoming National Biodiversity Strategy 2035 (Ministry of the Environment 2022), both coming into force in 2023, are the key institutional vehicles for this purpose.

Because biodiversity strategies do not operate in a vacuum, biodiversity, climate and sustainability concerns are intertwined and must be addressed simultaneously to be effective. Indeed, in this institutional transformation, mainstream economics has a role, but there is especially a call for economics understood as transdisciplinary science. The challenge becomes that of the co-design and collaborative implementation of more effective policy mixes (Barton et al. 2017) that extend beyond the hard regulation and soft governance divide in transforming the existing institutions and productive systems (Colander & Kupers 2014, Kupers 2020). In a similar vein, the Dasgupta Review (p. 483–496) invites us to seriously consider the options for change: to co-create remedies for the imbalance between our demand and nature's supply, to improve our understanding of progress and the measurement and financing of it, and to transform institutions for empowered citizens and nature-respectful education systems.

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6 Options for change: the Finnish perspective

Dasgupta presents two options for humanity (p. 487): either "we can continue down a path where our demands on Nature far exceed its capacity to meet them on a sustainable basis; or we can take a different path, one where our engagements with Nature are not only sustainable but also enhance our collective well-being and that of our descendants." Dasgupta guides the reader through the options humanity has for achieving the necessary change. These options for change (OC) can be clustered into three broad categories: (i) ensure that our demands on Nature do not exceed its supply, and that we increase Nature's supply relative to its current level; (ii) change our measures of economic success to help guide us on a more sustainable path; and (iii) transform our institutions and systems. These three categories are further divided into ten more detailed options for change. In the following, the ten options for change are introduced one by one. In the chapters, the Finnish experts on the options summarize how each OC is presently implemented in Finland. They provide research-based ideas and views on how to more efficiently and comprehensively implement the OC in the country. In addition, they discuss the required policy changes and needs for research information to implement the OC.

6.1 Nature's Supply: Conservation and Restoration of Ecosystems (Heini Kujala, University of Helsinki)

Summary of the option for change (OC)

The leading cause of biodiversity decline is habitat loss and degradation. To date, nearly three-quarters of Earth's surface has already been modified by humans (IPBES, 2019), and the degradation of ecosystems and natural habitats is continuing at an alarming pace, threatening human well-being. The Dasgupta Review outlines that in order to balance demand and supply, we need to ensure that Nature's ability to regenerate and to provide goods and services are not further weakened but instead strengthened. The two key mechanisms for achieving this are the preservation of the remaining natural habitats and restoration of those already degraded.

The backbone of preserving natural habitats is protected areas. According to the IUCN and UNEP-WCMC, approximately 16.9% of Earth's terrestrial areas and inland waters and 8.2% of its marine areas are currently protected. The Aichi Target 11 for 2020 to have at least 17% of terrestrial and inland waters and 10% of coastal and marine areas conserved was not reached. If the currently protected areas were to be the only areas left for nature, approximately 30–50% of the current species on Earth would go extinct (Hanski, 2000), leading to unpredictable and most likely catastrophic changes in ecosystems and services. Clearly, much larger areas are needed to preserve biodiversity and the services humans depend on. For this reason, the EU has already indicated that it will raise its regional targets for protected area coverage to 30% by 2030, while many scientists have advocated for an even more ambitious target of 50%, known as "Nature Needs Half".

We know from science that preventing the loss of existing natural habitats is far more effective and economically less costly than restoring already degraded or lost habitats. This is because 1) many biodiversity losses, even those taking place only locally, are irreversible, 2) restoration actions are expensive and time-consuming, often requiring repeated treatments, 3) restoring habitats is difficult and global reviews report that only 20–50% of restoration projects are successful (Maron et al., 2012), and 4) when successful, the recovery of natural habitats is usually slow, taking decades to centuries, depending on the ecosystem. However, the damage already caused to nature is so extensive that even if all further degradation was stopped, biodiversity would continue to be lost for decades to come (IPBES, 2019). Therefore, although priority should be given to conserving existing habitats, restoration will be a necessary complementary strategy in reversing the current biodiversity decline.

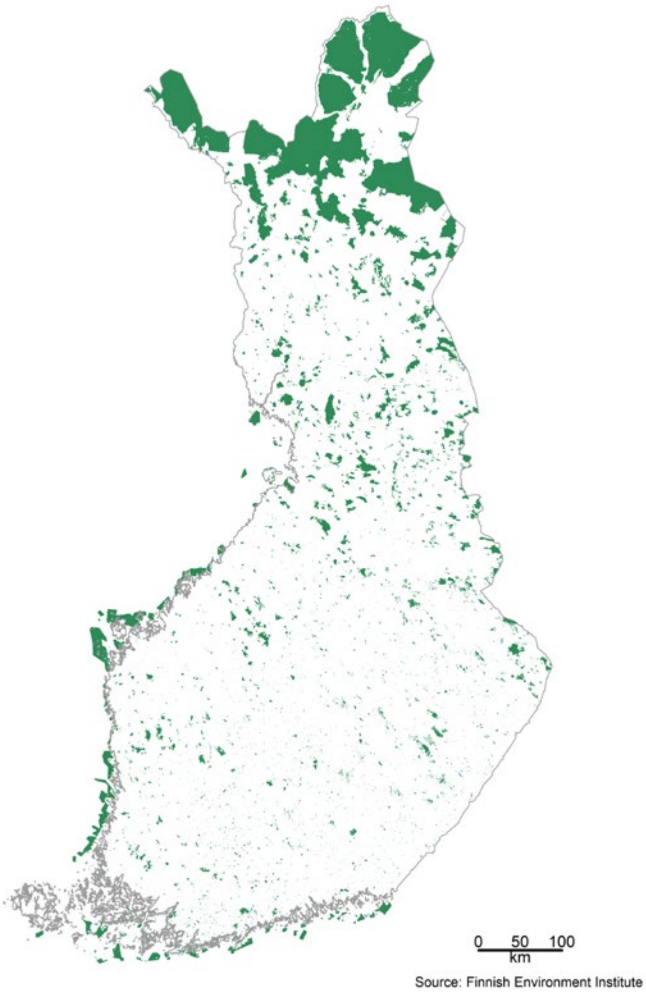
How the OC is currently implemented in Finland

Currently, approximately 13% of Finland's terrestrial areas and inland waters and 12% of its marine areas are protected (Kuusela et al., 2022). These include areas that are under temporary protection and those earmarked for protection but not yet designated as protected. The Finnish reserve network faces two challenges: 1) its extent is too small, far from the EU's 2030 biodiversity targets and not even reaching the Aichi 2020 target, and 2) the network is heavily skewed towards northern Finland (Figure 6). In southern Finland, meaning areas south of Lapland, Northern Ostrobothnia and Kainuu, all major biotopes (forests, mires, rocky outcrops, coastline habitats, agricultural habitats, inland waters and marine habitats) are currently insufficiently protected (Kuusela et al., 2022). In the south, the network remains highly fragmented, protected areas are small and far away from each other, and they are less likely to protect their biodiversity values from outside pressures.

The imbalance of the Finnish reserve network has been known for decades, but the expansion of protected area coverage in southern Finland has been slow. For example, during 1990–2015, the area of protected forests increased over two times more in northern Finland (~900,000 ha) than in southern Finland (~375,000 ha) (Korhonen et al., 2020). A major challenge is that most of the priority areas in need of protection in southern Finland are located on privately owned lands (Kuusela et al., 2022; Mikkonen et al., 2018). The soon ending Forest Biodiversity Programme METSO (2008–2025) was launched to increase the area of protected private forests in southern Finland on a voluntary basis by offering full financial compensation to private forest owners. The programme has been well received, but it has also been criticized for being under-funded, adding only 96,000 ha (<2%) of new area to the network in the course of 16 years. In comparison, to meet the EU's 10% target of strict protection, including all remaining old-growth forests, in just productive forestlands in a geographically balanced manner, an estimated additional 1,352,000 ha would need to be protected in the next 8 years (Kotiaho et al., 2021).

Historically, protection has been the primary conservation mechanism in Finland. The restoration of degraded habitats has focused on inland waters and been rather small scale, although its volume has slowly increased during the 21st century. The recently started HELMI programme (2021–2030) is the largest restoration programme launched so far. It aims to carry out restoration and management actions on 140,900 ha of forest, mire and agricultural habitats, 600 km of small creeks and in ~3,000 locations of coastal and freshwater habitats, both inside and outside protected areas. How much the recently proposed EU Restoration Law will introduce new restoration efforts on top of this is not yet known at the time of writing this report.

Figure 6. Distribution of current protected areas in Finland as defined in Kuusela et al. (2022)



How the OC could be implemented in a more comprehensive way

To secure its own nature supply, Finland will need to increase the extent and geographical representation of protected and restored areas. At its current rate, the country is unlikely to meet the new EU Biodiversity 2030 targets in the given time frame. This calls for a major shift in both the volume and diversity of conservation funding, but also the more cost-effective use of these resources.

Biodiversity and ecosystem services are never evenly distributed across landscapes. Strategic planning of conservation efforts that target highly biodiverse areas and prioritise the most impactful actions can significantly increase the biodiversity gains achieved in relation to euros spent. Without targeting, a larger area would be needed to obtain the same impact. In Finland, national analyses to support strategic planning have so far been conducted for forests, mires and marine environments (Moilanen et al., 2019). However, further efforts are needed to improve the data quality of these analyses, to cover currently un-analysed biotopes and, in particular, to improve the uptake and use of such information across administrative levels and sectors.

In theory, the fastest gains under this OC can be achieved through the protection and restoration of important biodiversity areas within government-owned lands, as this would shortcut the lengthy and often costly negotiations regarding land ownership and transfer. For government-owned forests, this will require strong political will power and the re-thinking of revenue expectations. Previous assessments also demonstrate that most of the remaining high-quality, non-protected habitats in southern Finland are located on privately owned lands (Kuusela et al., 2022; Lehtomäki et al., 2009; Mikkonen et al., 2018). Using only government lands to achieve EU targets is thus cost-inefficient. Nevertheless, public lands are intended to serve public goods. To efficiently increase nature's supply in a socially just manner, all opportunities to secure important nature locations on government lands should therefore be fully utilised in southern Finland.

There is a clear need for new and/or expanded avenues for private land protection and restoration in Finland. The experiences from METSO have been highly encouraging, but the limited budget and small targets mean that far fewer areas can be accepted into the programme than are currently being offered. An additional avenue could be the wider adoption of PES (payments for ecosystem services) schemes to attract more private landowners to protect, restore or sustainably manage their lands. With careful targeting of suitable locations, PES schemes and nature-based solutions can have co-benefits for biodiversity and services in many biotopes. These include the restoration of drained peatland forests and fields to reduce their carbon emissions, and the maintenance and restoration of mires and wetlands for flood prevention and water purification services. However, it is equally important to understand that PES schemes are no panacea. Because the schemes are dependent on landowners' willingness to participate, strategically best locations cannot be necessarily targeted, leading to cost-inefficiencies (Nieminen et al., 2021). PES schemes also need to be carefully governed if biodiversity benefits, or even the intended ecosystem services, are to be achieved (Naeem et al., 2015). Furthermore, not all ecosystem services can be efficiently transacted, and neither do all biodiversity values co-occur with services: these require additional protection through other mechanisms.

Unavoidably, these changes will require more conservation funds. For example, meeting the 10% strict protection target in a geographically balanced manner would require an estimated additional 760 million euros per year for forest habitats alone (Kotiaho et al., 2021). Cost-efficiently restoring only terrestrial habitats to achieve an average 15% improvement in their status is estimated to cost another 445 million euros per year (Kotiaho et al., 2015). The annual costs of the recently proposed EU Restoration Law are estimated to be 930 million euros for Finland (0.39% of Finland's GPD), although this largely consists of already ongoing efforts, and the truly additional costs introduced by the law currently remain unclear. In comparison, the current annual budgets of the METSO and HELMI programmes are 30 and 42 million euros, respectively. The above numbers are rough estimates, but they illustrate the wide gap between current and required efforts needed to reverse biodiversity decline in Finland. These conservation costs should also be balanced against their resulting benefits, including not only the monetary value of ecosystem services, but also the jobs and businesses they support and create.

Outside protected areas, Finland needs a transformative shift toward less destructive land-use practices. A key mechanism for this is the stronger adoption of the mitigation hierarchy, where biodiversity losses from human activities are first to be avoided, then reduced, and any remaining losses are compensated. Current land use laws and practices in Finland already utilise environmental impact assessments and permitting, but these do not effectively enough guide development to less harmful locations, because the monetary cost of biodiversity loss remains invisible in these assessments. Mandatory and scientifically designed biodiversity offsetting (ecological compensation) would make the accounting of losses and gains more transparent and, because of the high cost of offsetting, would probably motivate developers and planners to seek better avoidance and mitigation options. This can only happen if offsetting is not used to weaken permitting criteria, and if the true costs of offsetting are made explicit by demanding evidence of the ecological outcomes of offsets (Kujala et al., 2022; Spash, 2015). Stricter adherence to the mitigation hierarchy is a socially justified approach to increase the investment and responsibility of private sectors for biodiversity conservation and restoration, which is in line with the polluter pays principle. Avoiding biodiversity losses is also always less costly than attempts to restore the same losses afterwards.

Information needs

To cost-effectively improve Finland's nature supply, we need to know 1) where the most important biodiversity values are, so that we can protect them and avoid their degradation, and 2) where they can be most improved, so that we can restore them.

Finland has large amounts of biodiversity data, but they have not been collected in a systematic or coordinated manner. For this reason, i) the data are often not of the right type, for example, to support large-scale strategic planning, or ii) the information is not accessible to those making decisions that impact biodiversity, even within the environmental sector. Despite their large volume, biodiversity data in Finland are also still very much incomplete. Most notably, Finland lacks a comprehensive national map of its terrestrial biotopes, the simplest type of biodiversity data. Of the 48,000 species currently found in Finland, we only have reliable distribution data for some hundreds (birds, vascular plants), but even for these, the data do not cover the whole country at a spatial resolution relevant for land use planning. Thanks to the Finnish Inventory Programme for Underwater Marine Diversity (VELMU), we now know more about the distribution of underwater nature along the Finnish coastline than we do about our terrestrial biodiversity. A similar programme to VELMU, in which species and habitats are systematically monitored across the country, is desperately needed for Finland's terrestrial biodiversity.

Data should also be accessible to those who need it. Because of missing data interfaces, old protocols and fragmented governance across multiple administrations (e.g., regional forest and ELY centres), gaps in information transfer still persist, leading to biodiversity losses that could have been avoided. The establishment of the Finnish Biodiversity Information Facility FinBIF (Lajitietokeskus) has been central for bringing together existing species data across numerous sources, improving their accessibility and use. The recently launched Finnish Ecosystem Observatory (FEO) is a new major initiative to further improve the uptake and use of these data through the development of targeted policy interfaces. Combining data from FinBIF and other data providers, FEO also aims to develop new monitoring tools, such as remote sensing and system modelling, which may in the future provide more information on biotopes and ecosystems. Together, large biodiversity infrastructures such as FinBIF and FEO are essential in collating and summarising current knowledge and up-scaling its use. However, they alone cannot fix existing information gaps and will always be dependent on the data collected through field surveys, monitoring programmes and biological collections.

In addition to systematically mapping its terrestrial biodiversity values, Finland needs to start collecting data on the success and impact of different conservation actions. Restoration and habitat management has been relatively small scale in Finland so far, but as these will become a more central conservation tool in the future, we need to have a better understanding of which actions work and where.

Lastly, it has to be noted that the vast majority of Finnish biodiversity data are currently collected by volunteers and citizen scientists. Even FinBIF, our only currently operational biodiversity data infrastructure, runs on insecure project funding. Similarly, FEO's funding is fixed-term. Biodiversity is vast, and not everything can be surveyed. However, biodiversity also drives our economy and well-being, and this should be reflected in our efforts to monitor its state.

Table 1. Examples of governance activities for securing and strengthening the supply of nature in Finland.

Objective	Operational (less than 5 years)	Tactical (5–10 years)	Strategic (15–30 years)
Protection of current natural habitats	Protect remaining high-quality areas on government lands, with an emphasis on southern Finland Create strategic plans for cost-effective targeting of protection using existing data (updated every 5 years)	Extend and significantly expand private land conservation schemes such as METSO Initiate new, scientifically sound private land conservation schemes (e.g., PES) Produce a national map of biotopes	Strategically expand protected area coverage to meet at least 30% of Finland's land area Establish a national programme to survey terrestrial biodiversity in Finland
Restoration of degraded or lost habitats	Create strategic plans for cost-effective targeting of restoration and management (updated every 5–10 years) Secure and expand state funding to support larger numbers of EU Life projects Increase the number of trained restoration professionals	Strategically restore degraded areas inside protected areas Combine the benefits of restoration and nature-based solutions to find win–win opportunities for humans and nature (e.g., flood prevention and water purification through mire and wetland restoration) Systematically collect information on restoration success and impacts in different habitat types	Extend and expand restoration programmes, with increasing consideration of climate change impacts on nature

Objective	Operational (less than 5 years)	Tactical (5–10 years)	Strategic (15–30 years)
Reducing habitat loss outside protected areas	Remove or reduce economic profit requirement from state forest management Remove the most harmful subsidies that cause habitat loss (e.g., support for new draining of mires and wet forests) Strengthen the adoption of mitigation hierarchy in land use, including voluntary biodiversity offsetting Close the remaining gaps in biodiversity information transfer between FinBIF and private and public land use sectors	Introduce biodiversity accounting to all state-run operations Tighten requirements for impact avoidance and mitigation measures in land use planning Make biodiversity offsetting mandatory Produce a national map of biotopes Secure the permanency of FinBIF and FEO	Significantly increase biodiversity knowledge in all administrative levels and sectors of land use (private and public) Establish a national programme to survey terrestrial biodiversity in Finland

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6.2 Our Demand: Changing Consumption and Production of Food Patterns (Markus Vinnari, University of Helsinki)

Summary of the option for change (OC)

Dasgupta states that modern agriculture has driven much of the environmental decline. He states that monocultures have been effective in providing food, but they have been harmful for biodiversity. Dasgupta also highlights the need to change the balance of crops intended for human consumption and animal feed. When evaluating effective ways to reduce the ecological footprint of food consumption and production, there is ample research demonstrating that we particularly need to reduce the consumption of animal originated food (Poore and Nemecek 2018; Westhoek et al. 2014).

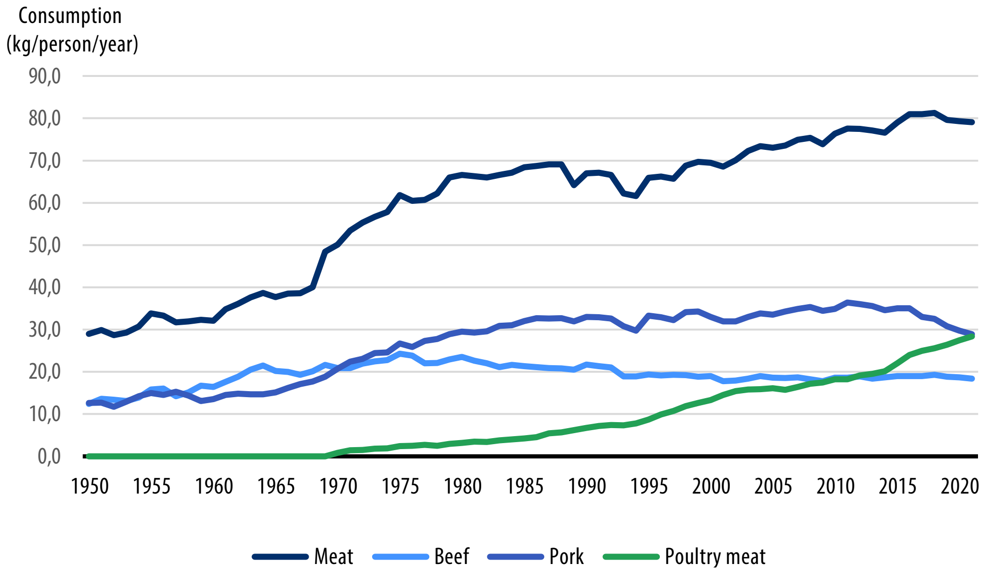
Summary of the option for change (OC)

- Support the transition of production and consumption to sustainable levels
- Restoration of land through habitat management and rewilding is needed
- Transform education (both values and abilities) to better acknowledge biodiversity
- Empower citizens to make more informed food choices
- Transform food supply towards plant-based products
- Increase financing to achieve more sustainable food production
- Technological innovations, such as vertical farming and meat analogues, can reduce biodiversity loss

How the OC is currently implemented in Finland

A key way to decelerate biodiversity loss is to reduce meat consumption both on the global scale (Machovina et al. 2015) and in the European context (Crenna et al. 2019). This is also the case in Finland, where annual meat consumption has been around 80 kilograms per capita during the last decade (see Figure 7). About 20 kilograms of this is beef, about 30 kilograms is pig meat and about 30 kilograms is broiler meat. Compared to other EU countries, meat consumption in Finland is rather average. However, milk consumption in Finland is the highest in the world. It should be acknowledged that, for example, tea, coffee and chocolate also have a relatively high biodiversity effect when considering Finnish food consumption (Sandström et al. 2017).

Figure 7. Meat consumption per person in Finland 1950–2021 (Luke 2021)



Source: Natural Resources Institute Finland, Balance sheet for food commodities.

It is sometimes argued that cattle grazing can positively affect biodiversity in some ecosystems and geographical areas. This seems to be true for Finland, but the actual number of cattle needed to preserve traditional rural biotopes appears to be small, being about 20,000 heads according to some estimates, compared to the current number of cattle in Finland, which is about 900,000 heads (Raatikainen 2019). In some areas, benefits can be achieved, for example, by reaping or rewilding, so there is a need to analyse where cattle are actually beneficial. Even though there might be biodiversity benefits from some degree of cattle farming, in general, a decrease in animal originated food production and consumption is needed. This is because a smaller cultivation area is needed when consuming a more plant-based diet (for calculations of the land use needs of different diets and effects on the security of supply, see Saarinen et al. 2019).

Currently, some actions are being taken to decrease the consumption of animal originated food. For example, some cities are active in promoting vegetarian days in schools and they are at least offering vegan options to the pupils who ask for them. There is also some government funding to promote research on novel protein sources, such as new plant-based foods and proteins based on cell cultivation. These actions could benefit from a more systematic approach to their implementation.

How the OC could be implemented in a more comprehensive way

Food consumption and production systems are complex. Many population-level changes can take a long time. Substantial changes are, however, possible. One example is the rise in broiler production and consumption in Finland. Broilers were introduced to Finnish dinner tables in the 1960s, and it took a relatively long time before their production and consumption started to reach significant levels (see Figure 7). Today, they comprise a third of Finnish meat consumption (Luke 2021).

To effectively influence food production and consumption, we need to devise options for different time scales: operational (effective in less than five years), tactical (effective in five to ten years) and strategic (effective in 15–30 years). Table 2 summarizes activities to influence consumption patterns and Table 3 production patterns.

Table 2. Examples of governance activities for enabling a transition towards the consumption of plant-based foods (Vinnari and Vinnari 2014, modified and updated)

Objective	Operational (less than 5 years)	Tactical (5–10 years)	Strategic (15–30 years)
Transforming education	Education about the relationship between biodiversity reduction as well as climate change and food consumption in schools Education about animal capabilities (such as intellect and the feeling of pain) and including production animals in this education	Acknowledging food production and animal farming in school curricula Highlighting (animal) ethics, e.g., in biology and home economics classes Including the preparation of vegetarian dishes in the training programmes of catering professionals	Dissemination of information about historically utilised (plant-based) foodstuffs
Empowering citizens to make informed choices	Creating nudges (e.g., better availability) and incentives to use plant-based foods in public restaurants Making plant-based options available in public catering including schools	Animal welfare labels on packaging or pictures of actual living conditions in supermarkets Labelling that helps consumers to identify meat products that benefit traditional rural biotopes ("less, but better") Prohibition of advertising for animal products that misrepresents animals, or the complete prohibition of the advertising of animal-originated products	Global initiatives to promote citizen participation in food production, i.e., urban farming or farm visits (WHO, UN)

When discussing social change, the Dasgupta Report emphasizes the importance of education (see chapter 6.10) and finance (see chapter 6.8), as well as empowering citizens (see chapter 6.9) to make informed choices. Below, governance options are provided for each of these, complemented with the theme of steering supply, which is a key factor in the context of food production. To begin from the guidance of consumption through education, more information could be provided in schools about the relationship between biodiversity loss and food consumption. In addition, giving pupils information about the capabilities of non-human animals and especially production animals can enable an easier transition towards plant-based diets. Education of catering professionals to prepare tasty plant-based meals is a critical step in securing the know-how of future generations of restaurant professionals. Disseminating information about historically used foodstuffs can enable the transition of some consumers to more plant-based traditional diets (Ljokkoi et al. 2021).

The Dasgupta Report also acknowledges that many human preferences are socially embedded. Human motivations and preferences are influenced by the actions of others. Therefore, empowering citizens to make informed choices can have a relatively large influence on their decisions. Scientific experiments have indicated that nudging can have a positive effect on, for example, what customers decide to order in restaurants. Just making the plant-based option the default in schools can increase its consumption, even though animal-based foods would also be available. Animal welfare labels on food packaging could also foster informed decision-making. Labelling could additionally be used to promote meat products that benefit traditional rural biotopes. This labelling can be challenging, because of the lack of consumer understanding of the issue or because of the difficulties in finding relevant criteria (Stampa and Zander 2022).

As regards food production, ways of transforming the supply include the acknowledgement, or even endorsement, of plant-based diets in national food recommendations and supporting research concerning the health effects of plant-based diets. Financial means of steering production towards plant-based foods include supporting farmers and the agro-industry during the transition period, providing financial incentives for the development of plant-based protein sources, as well as reducing government subsidies for animal-based food production (for a more comprehensive list of the possible financial options available, see Halonen et al. 2022). For example, considering plant-based protein as a cluster that is given special policy attention could be one option. Taxation of animal originated food products has also been proposed (Funke et al. 2022). For a discussion on the pricing of externalities, see chapter 6.4 of this report.

Table 3. Examples of governance activities for enabling a transition towards the production of plant-based foods (Vinnari and Vinnari 2014, modified and updated)

Objective	Operational (less than 5 years)	Tactical (5–10 years)	Strategic (15–30 years)
Transforming supply	Advice for cooks about preparing healthy plant-based meals in schools and public restaurants	More in-depth acknowledgement of plant-based diets in national food recommendations	Financing research into the nutritional effects of plant-based diets
Transforming finance	Finding ways to support farmers in transforming their production Incentives for utilizing and improving current plant-based protein sources (hemp, soy, wheat (seitan), beans, lentils, etc.)	Support for the agro-industry in the transition period (formation of Finnish plant-based protein cluster) Incentives for the development of novel plant-based protein sources (lupine, mycoprotein, etc.), as well as public funding for domestic protein isolate plants Meat taxation	Decreasing subsidies for animal-originated food stuff production on a global scale Incentives for the development of *in vitro* meats and other cellular agricultural products

Information needs

- Comprehensive analysis of the actions that are already being taken at different levels of society to decrease and increase animal originated food production and consumption.
- Research (peer reviewed, international) into the biodiversity effects of Finnish food production and consumption, especially the biodiversity effects of meat and dairy production.
- Research into the land use needs of new proteins (including vegetable proteins and cell-based foods).

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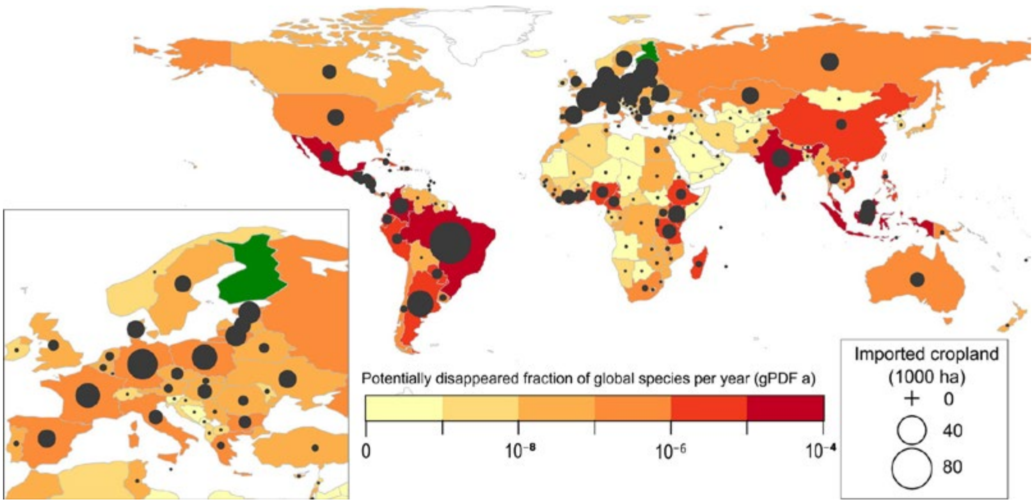
6.3 Trade and Supply Chains (Sami El Geneidy, University of Jyväskylä)

Summary of the option for change (OC)

Trade increases economic activity and thereby increases pressure on the biosphere. It also allows biodiversity impacts to concentrate on certain areas, generating local biodiversity problems. On the other hand, trade helps to spread new technologies that may reduce the pressure. The global and local net effects on biodiversity depend on how we manage the effects along the supply chain. Globally, around 30% of the threats to species are mediated by international trade (Lenzen et al., 2012). While global trade has expanded, the backbone of its functions, supply chains, have also become increasingly complex. More industrialized economies, such as Finland, have become net exporters of environmental impacts, i.e., a large share of their environmental impacts are outsourced by importing goods and services produced in other countries (Marques et al., 2019, Sandström et al., 2019). For example, Marques et al. (2019) estimated that in 2011, 33% of the biodiversity impacts in Central and Southern America and 26% of the impacts in Africa were driven by consumption in Europe, North America and the Asia-Pacific region. In Finland, Sandström et al. (2017) found out that more than 90% of the biodiversity impacts of food consumption take place outside Finnish borders (Figure 8). It is vital to consider trade and supply chain practices when designing policies to halt nature loss arising from Finnish consumption.

Figure 8. The imported cropland (circles) and global biodiversity impacts due to land use (colour scale) of Finnish food consumption in 2010 (Sandström et al., 2017).



How the OC is currently implemented in Finland

One of the major regulations against trade-induced biodiversity loss in Finland and globally is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). While the Convention effectively regulates the trade of species, it falls short of protecting the habitats of the very same species it tries to protect, which are affected by international trade in commodities that exploit the resources in those habitats (Lenzen et al. 2012).

Aspects of biodiversity have also been included in regional trade agreements. Velut et al. (2022) analysed sustainable development provisions in free trade agreements (FTA). They found that ten out of eleven EU FTAs cover biodiversity protection and nine cover illegal trade in endangered species. However, it has been argued that, for example in the case of the EU-MERCOSUR (Brazil, Argentina, Uruguay and Paraguay) trade agreement, there are no effective enforcement measures to ensure the implementation of the sustainability commitments (Kettunen et al. 2020). The European Commission has recently established an action plan for better implementation of sustainability aspects in trade agreements, for example by extending the possibility to apply trade sanctions when sustainability targets of the trade agreement are not met.

Environmental due-diligence initiatives, targeted at corporate supply chains, have been instituted in the EU, but are mainly sector specific, such as the EU Timber Regulation, the EU Conflict Minerals Regulation and a proposal for regulating commodities affecting deforestation, such as beef, palm oil, soy, cocoa and coffee. In Finland, national due-diligence legislation, i.e., the Corporate Responsibility Act, has been planned for some time, but as of now has not been implemented. However, a proposal for similar legislation at the EU level has been officially supported by the current Finnish government.

Finnish corporations have included aspects of biodiversity in their supply chain sustainability policies. Many policies rely on existing certification schemes (e.g., Fairtrade, Forest Stewardship Council, Rainforest Alliance, Roundtable on Sustainable Palm Oil) and aim, for example, to increase the share of certifications. In addition, companies aim to enhance the due diligence of suppliers with code-of-conduct policies and increased communication. Lähtinen et al. (2016) assessed the biodiversity and ecosystem services supply chain policies of global forest industry, including two Finnish companies, UPM and Stora Enso. They concluded that while companies had included biodiversity and ecosystem services in their reporting schemes, the reporting focused on positive initiatives and neglected, or provided ambiguous information on, the negative impacts of supply chains. The Finnish non-governmental organization Finnwatch assessed the quality of 18 certification schemes (Finnwatch 2022), finding that 11 certification schemes included some aspects of biodiversity protection or deforestation, but 7 did not include any such aspects. As Quarshie et al. (2018) concluded in their analysis of the biodiversity policies of two Finnish corporations' (UPM and Soilfood) supply chains, halting global biodiversity loss needs more than voluntary corporate actions.

How the OC could be implemented in a more comprehensive way

Policy recommendations are summarized in Table 4. A clear issue with enhancing trade policies is that it might be difficult to initiate change as an individual country. Thus, it is important to communicate and network with others to facilitate change on a larger scale and call for changes in the EU and World Trade Organization (WTO). One possible option to better include the prevention of biodiversity loss in trade policies would be border adjustment taxes, where commodities are taxed based on where they are consumed rather than produced. Similar taxes have been planned in the EU in terms of climate emissions arising from imported products. This so-called carbon border adjustment mechanism could also be applied to biodiversity. In fact, in future analyses and policy considerations of similar mechanisms, it will be vitally important to analyse climate and biodiversity issues alongside each other (Pörtner et al. 2021). Dasgupta argues that border adjustment taxes can be politically challenging, as they might appear discriminative and invoke 'protectionism' among countries. To overcome such challenges, an alternative could be to tax imports and domestic products equally based on their environmental impacts (Bellmann et al. 2019).

Positive incentives can also be used to guide corporate supply chain biodiversity policies. One such option could be sustainable commodity import guarantees (Global Resource Initiative 2020). The idea is that trade financing (loans) for commodities that are proven to be sustainable (e.g., through a biodiversity footprint analysis) would receive government guarantees, thus reducing risks for the lending institution and consequently improving the market position and pricing of the commodity.

Dasgupta raises concern that the proper implementation of a tax (or an incentive) would need to take into consideration the exploited ecosystem types and level of degradation over time, i.e., the biodiversity footprint of the taxed commodities or the cost of externalities. However, research and development on assessment of the biodiversity footprint of commodities and business activities is well underway in Finland (El Geneidy et al. 2021) and around the world (Marques et al. 2017).

To understand the biodiversity footprint of trade in Finland, it would be important to systematically follow Finland's consumption-based biodiversity footprint (see National Footprints chapter 3.1). Similar initiatives in terms of carbon footprints have already been taken, for example, in Sweden, and consumption-based national carbon footprint assessments have also been conducted in Finland (Nissinen and Savolainen 2019). However, the official integration of such assessments, especially in terms of biodiversity, in national statistics is still lacking, and Finland could take a leading role in this regard.

Moving from trade to corporate supply chains, one of the main issues with current and planned regulation for corporate supply chains is that the regulation does not explicitly tackle the issue of overconsumption of natural capital in supply chains. The regulation focuses on certain key sectors rather than looking at the holistic biodiversity impacts of supply chains, ignoring the peril of the "common" nature. Again, to overcome such issues, indicators and tools are needed to measure the holistic biodiversity footprints of supply chains.

Ensuring the comparability of biodiversity (and carbon) footprint analyses between different organizations (e.g., corporations, private and public institutions, non-governmental organizations) can be challenging. Financial accounting and reporting is heavily standardized and regulated, and anything an organization produces or consumes should be visible in its financial accounts. By exploiting this feature, organizations can assess and report their environmental impacts based on their financial accounts (El Geneidy et al. 2021). Environmental accounting could even utilize the unique feature of financial accounting: double-entry bookkeeping (where money was taken from and where it was used). A double-entry bookkeeping system in environmental accounts would not only ensure the assessment of biodiversity footprint flows (i.e., negative biodiversity impacts of consumption), but also changes in assets, that is, natural capital (Capitals Coalition 2022). The system could even be used to evaluate the positive impacts of organizations based on how they manage their natural capital and what cumulative effects their produced products and services have in society. The role of national policymaking could be to make binding regulation that ensures standardized environmental accounting is mandatory for all organizations with financial accounts. In fact, large corporations around the world (Finnish signatories: S Group, Valio, Stora Enso and Lassila & Tikanoja) are demanding that governments make assessments and the disclosure of impacts and dependencies on nature mandatory (Business for Nature, 2022).

Table 4. Policy recommendations for strengthening the inclusion of biodiversity aspects of trade and supply chains in Finland.

Objective	Operational (less than 5 years)	Tactical (5–10 years)	Strategic (15–30 years)
Trade	Support the inclusion of biodiversity aspects in the EU carbon border adjustment mechanism Support the expansion of CITES to include more species that are threatened by international trade	Support the implementation of a non-discriminatory tax on both imports and domestic commodities based on their assessed biodiversity footprint in the EU Support the implementation of sustainable commodity import guarantees to incentivize and enhance the market position of sustainable imports in the EU	Support the inclusion of biodiversity aspects in trade agreements
Supply chains	Start systematic assessments of Finland's national consumption-based biodiversity footprint Support the EU due-diligence law proposal	Initiate national policies and standardization of mandatory biodiversity footprint assessments in all organizations, starting from large organizations Initiate national policies for the integration of financial and environmental accounting, starting from large organizations	Constrain overconsumption of resources in supply chains by regulating the consumption of commodities according to the limits set by local and global biodiversity

Information needs

To better facilitate the urgently required policy changes in supply chains and trade, more information and research is needed on biodiversity footprint assessments and on the social, political, environmental and economic consequences of implementing environmental tax policies in trade. In addition, ecosystem accounting initiatives provide crucial information needed for further improving biodiversity footprint models. However, as this chapter highlighted, adequate information to reduce the pressure of trade and supply chains on biodiversity already exists and needs to be implemented.

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6.4 Pricing environmental damage (Marita Laukkanen, VATT Institute for Economic Research)

Summary of the option for change

The production, consumption and exchange of goods and services by firms or persons may have consequences for others that are not accounted for in market prices. These consequences are called externalities in economics parlance. Externalities may be negative or positive. To illustrate, consider the revenue and costs of a landowner's decision to use a wetland for peat extraction. The landowner's profitability comparisons typically do not include environmental damage, i.e., the biodiversity loss caused by peatland drainage, peat extraction and emissions to watersheds. These are negative externalities that are not compensated to those affected by the decline in biodiversity.

Pricing of the externalities can be a useful instrument for reducing environmentally damaging activities (negative externalities) or for increasing environmentally beneficial activities (positive externalities). In the case of negative externalities, taxes would induce firms and persons to account for the damage inflicted on others; in the case of positive externalities, subsidies would induce them to account for the benefits conferred on others. If firms and people pay the social cost of resources they use – that is, if full transaction prices capture the value of externalities – potential externalities are "internalized". Firms and people are made responsible to others for what they produce and consume.

How the OC is currently implemented in Finland

Both environmental taxes and environmental subsidies are currently implemented in Finland. This chapter focuses on the pricing of negative externalities in the energy and transport sectors through environmental taxes, as other sectors and pricing instruments relevant to them are discussed elsewhere in this report.

Finland has environmental taxes on energy, transport, emissions and resource use. In 2020, environmental taxes totalled 6.5 billion euros, about 6.6% of Finland's total tax revenue and 2.7% of Finland's GDP. At 4.6 billion euros, energy taxes were the largest source of environmental tax revenue. Taxes on transport comprised 1.9 billion euros. Thus, almost all environmental tax revenue stemmed from energy and transport taxes (Statistics Finland 2022).

Energy taxes include transport fuel charges based on fuel CO_2 emissions and energy content. In addition, cars are subject to a one-time vehicle new registration tax and an annual vehicle tax. Energy taxes also apply to fuels used in heat generation and to energy use by manufacturing. Similarly to transport fuels, taxes on most heating fuels are based on fuel CO_2 emissions and energy content. Energy used in electricity generation is not subject to energy taxes, but the CO_2 emissions from the fuels used are priced through the EU emissions trading system. These emission charges are also included in the reported total energy tax revenue (Statistics Finland 2022).

We next compare the Finnish tax levels with the estimated value of the damage generated by CO_2 emissions. A historic low-end estimate for the social cost of CO_2 emissions is 30 euros/tCO_2, a mid-range estimate 60 euros/tCO_2 and a high-end estimate 120 euros/tCO_2 (see OECD 2021, High-Level Commission on Carbon Prices 2017 and Tol 2018). Considering mid-range estimates for the social cost of CO_2 emissions, the taxes and emission charges fully capture climate damage for heating fuels in installations included in the EU emissions trading system and for transport fuels. The combustion-based CO_2 tax on transport fuels is 92 euros/tCO_2 and that on heating fuels 64 euros/tCO_2. For heat generation exempt from the EU emissions trading system, climate damage is not fully captured at the higher range of externality estimates. This also holds for electricity at average 2022 emission permit prices of 80 euros/tCO_2 (source: Energy Authority 2022). Importantly, in terms of the environmental component, the energy tax base is defined in terms of CO_2 emissions from energy use, while biodiversity impacts are not accounted for.

There are several exceptions and omissions in the energy tax system that are important in terms of biodiversity loss and in part also in terms of CO_2 emissions. First, energy taxes on peat do not follow the general energy tax schedule. Energy taxes on peat converted to a CO_2 tax correspond to about 18 euros/tCO_2, which is far below even the low-end estimates for the social cost of CO_2 emissions. This means that climate damage is only partially accounted for. Damage pertaining to biodiversity loss caused by peat extraction is not accounted for at all. Second, wood fuels are not taxed. This means that indirect carbon emissions and biodiversity loss produced by wood fuels are not priced. The use of wood biomass for energy interacts with the use of wood biomass in the forest industry, which is also not taxed to account for environmental damage. Third, environmental damage associated with wind and hydro power is not priced. While these modes of electricity generation do not produce direct CO_2 emissions, they can have negative impacts on biodiversity through animal displacement, land take and river damming that are currently not appropriately accounted for. Fourth, energy-intensive manufacturing firms are entitled to exemptions on energy taxes that reduce effective taxes on fossil fuels and peat, which widens the gap between the effective tax rates on fuels used in heat generation and the associated environmental damage. However, the exceptions are to be phased out by 2024.

There are also exemptions on taxes on transport fuels that dilute the pricing of environmental externalities. Most notably, externalities from CO_2 emissions from the aviation and maritime sectors are not fully priced. There are also tax exemptions on commuting travel and subsidies on goods transports. Assessing the implications of these measures on the overall pricing of CO_2 emissions is not straightforward and is not addressed here.

New ideas and information needs

Finland can be seen as a front-runner in pricing externalities from CO_2 emissions from energy and transport. However, damage pertaining to biodiversity loss remains largely unaccounted for. There are both synergies and tradeoffs between climate and biodiversity objectives. Externalities from peat extraction comprise climate and biodiversity damage. Leaving retention trees and decaying wood in place after felling would be beneficial in terms of both carbon and biodiversity. Hydro and wind power help mitigate CO_2 emissions but can have negative biodiversity impacts.

Damage from CO_2 emissions and biodiversity loss differs in a way that has important implications for pricing. While much uncertainty and gaps in knowledge remain in terms the economic damage from climate change, the contribution of CO_2 emissions to climate change is the same regardless of where the emissions were produced. However, biodiversity varies locally, which means that the social cost of activities causing biodiversity loss would need to be assessed accounting for local site characteristics. Furthermore, activities and choices causing biodiversity loss are often discontinuous, such as taking land for peat extraction or the construction of wind farms, roads or railways. Pricing biodiversity impacts would change the profitability calculations and decisions as to whether an investment is profitable in terms of the sum of the market value of the project and the damage from biodiversity loss. Correctly pricing biodiversity impacts would require reliable assessment of both the local effect of the activity on biodiversity and the local value of biodiversity. The information needs are vast. Local extinction of species can also occur with a substantial delay following habitat loss or degradation, posing another challenge to correctly estimating the effect of environmental changes on biodiversity (Kuussaari et al. 2009).

That said, the energy sector already has taxes in place that seek to price environmental damage. These taxes only account for climate impacts, and in many cases only partially. Including a biodiversity component in the energy tax on peat and considering an energy tax on wood fuels that would account for both climate impacts and biodiversity could be an option for change worth considering. Such taxes could reduce environmentally damaging activities in such a way that the societal gains from doing so would be greater than the societal losses, even if the taxes did not price the externalities fully correctly.

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6.5 Future Population and Option for Change for Finland (Milla Nyyssölä, The Labour Institute for Economic Research LABORE)

Option for change for Finland

On 15 November 2022, the UN announced that the global population had reached 8 billion people (https://www.un.org/en/dayof8billion), amplifying the impact of economic development on nature and the environment. Since then, the Neo-Malthusian voices have become louder concerning the impact of population growth on 'environmental destruction'. Finland is a developed country in a stage of demographic transition characterised by decelerating population growth. Although population growth magnifies the ecological impact of economic development, rising per capita income is the primary driver of unsustainable production and consumption patterns. The countries with the highest per capita consumption of material resources and greenhouse gas emissions tend to be those where income per capita is higher, not those where the population is rapidly growing. Within Finland, regional depopulation poses specific challenges and opportunities for augmenting biodiversity. Planning and resources are needed to ensure that depopulating areas bring desirable ecological dividends (Matanle 2017). The option most pertinent to Finland regarding alleviating global rising population pressures is to try to affect demographic change for it to transition from one stage to another, ultimately reaching slower population growth through active advocation, development cooperation and private sector impact investment, especially where the need for change is highest, combined with the significant potential for slowing down biodiversity loss, i.e., biodiversity hotspots and major wilderness areas (especially in Sub-Saharan Africa and South Asia; see, e.g., Johnson et al. 2021). While openly influencing population growth in another country remains problematic, especially in the sphere of development cooperation (see, e.g., Bendix and Schultz 2018), supporting fair and equitable human development and investing in human capital is vital for societies in all stages of the demographic transition (for which the theory was first suggested by Frank Notenstein in 1951; see more in Kirk 1996).

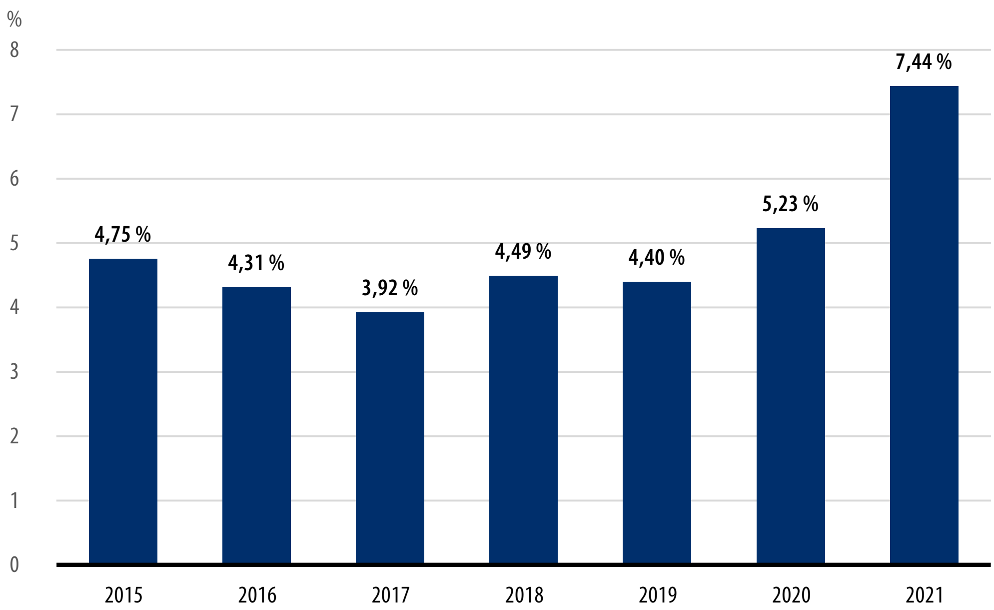
The literature states that the empowerment and education of women and girls are among the main drivers of demographic change, further accelerated through the process of urbanisation and structural change. Furthermore, fostering gender equality through more gender-sensitive policies and programmes, for example, in social protection, health, employment and leadership, is critical. A more direct, measurable and effective impact tends to be achieved by promoting women's sexual and reproductive health and rights (SRHR). As there is no silver bullet for accelerating demographic change cost-effectively and ethically everywhere, supporting progress on several fronts through customised, evidence-informed approaches would be the way forward.

How the OC is currently implemented in Finland

Most of the development aid that Finland currently provides has the potential to support demographic change. As the most significant part of official development assistance (ODA) already goes to strengthening the status and rights of women and girls (32%), education, well-functioning societies and democracy (27%), and climate change and natural resources (21%), it is essential to begin by looking at the trends in the total value of ODA. Total ODA and its share of GNI (with a target share of 0.7%) increased almost yearly until the sizeable budget cuts in 2015–18. While the Government has tried to reverse the development and steadily raise the contribution, the highest levels have not been reached since then (in 2014, ODA/GNI was 0.59%) (MFA 2022). Furthermore, the government recently agreed to undertake significant budget cuts in development aid, fixing the expected ODA/GNI share at 0.45% for 2023–26.

The share of Finnish ODA in all education-related programmes has been on the rise over the past few years (see Figure 9). The growth was especially notable from 2020 to 2021, when the total value of educational disbursements rose by 54%. Finnish education exports have also been a field gaining increasing traction in the past.

Figure 9. Share of total ODA allocated to education, disbursements

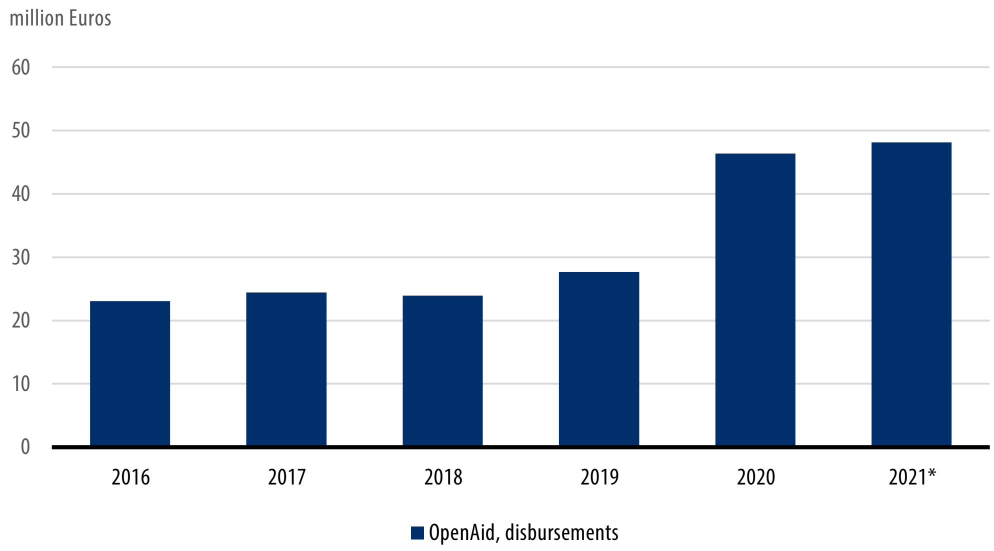


Source: author's illustration using data from OpenAid.fi.

Strengthening the status of women and girls is an essential precondition for demographic development. On a positive note, gender equality is a priority area in development policy (MFA 2022). The ODA share of this policy priority has been significant, between 30% and 40% for the past seven years. The funding is directed to the United Nations, World Bank, European Union institutions, regional development banks, other multilateral institutions, NGOs and public sector institutions.

The priority area mentioned above also comprises the sexual and reproductive health and rights (SRHR) of women and girls.[1] Finland promotes these comprehensively, including support to SRHR-related legislation and policies, but also sexual health services and comprehensive sexuality education, including learning about consent, contraception, maternity health services and the right to safe abortion, among others. This also includes aid in preventing sexual and gender-based violence and improved access to services for its victims. Figure 10 illustrates the development of Finnish ODA commitments to SRHR using development cooperation disbursement data from the Ministry for Foreign Affairs of Finland Databank (MFA 2022). Finland's disbursements have been increasing during the past years.

Figure 10. Finnish ODA allocated to SRHR, disbursements from OpenAid.fi

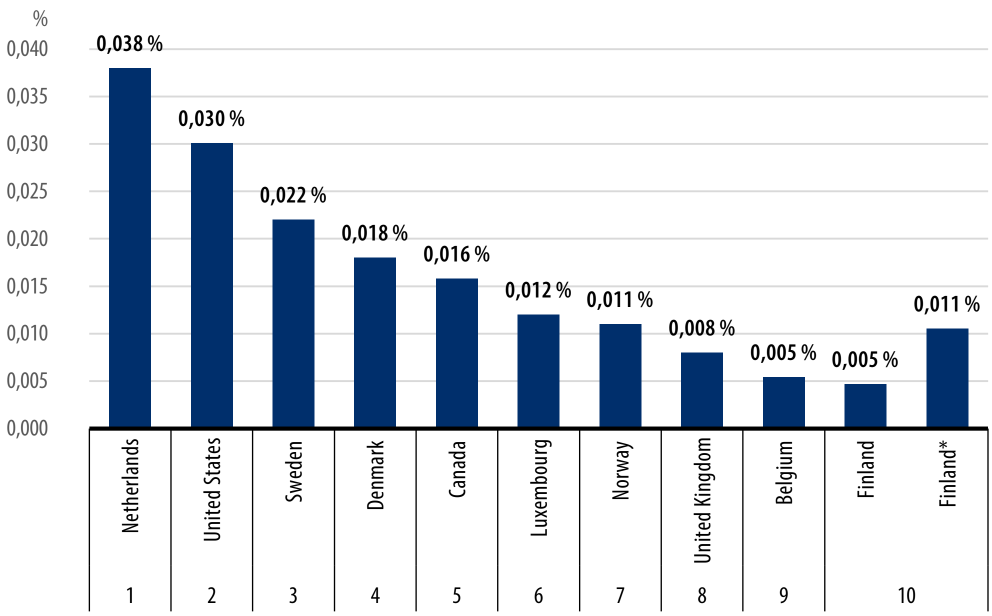


Source: author's illustration using data from OpenAid.fi. * 2021 figure is based on preliminary data.

1 See more here: https://um.fi/sexual-and-reproductive-health-and-rights-srhr-in-finland-s-development-policy.

The share of total ODA allocated to population policies/programmes and reproductive health (equal to SRHR in Finland) has been around 4% during the past two years (see Figure 13). Internationally, the best-performing donors had a share of nearly 5% in 2019 (DSW 2021). Finland held the tenth position among all donors according to QWIDS data on commitments, measured by the average 5-year SRHR ODA/GDP ratio from 2016 to 2020. If commitments are substituted by disbursements for the case of Finland, relative to GDP, Finland ranks eighth (i.e., 0.01% of GDP), right after Norway. There is considerable room for improvement; for example, the Netherlands invests four times more in SRHR relative to GDP per capita (Figure 11).

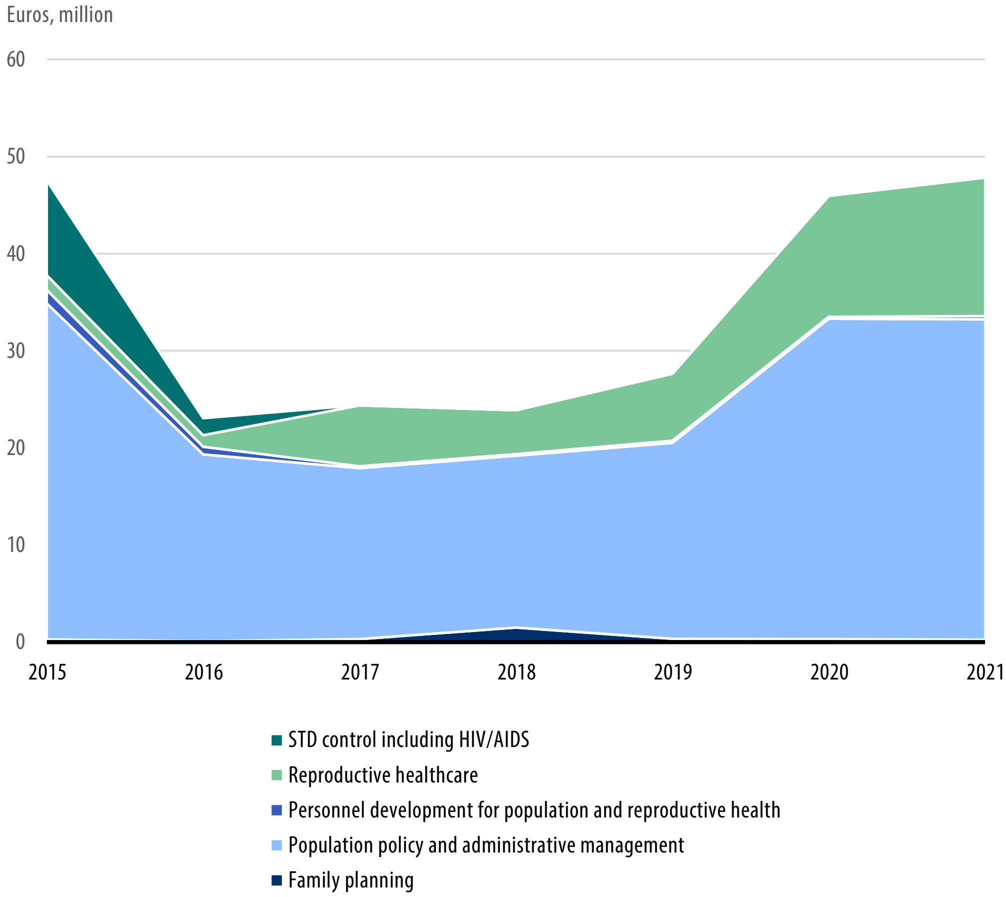
Figure 11. The average share of population policies/programmes & reproductive health in the total commitments of GDP during 2016–20 (as reported in the QWIDS database)



Source: Figure created by the author using ODA commitments from the QWIDS database and https://data.worldbank.org. . * Figure is created using ODA disbursements data from OpenAid.fi.

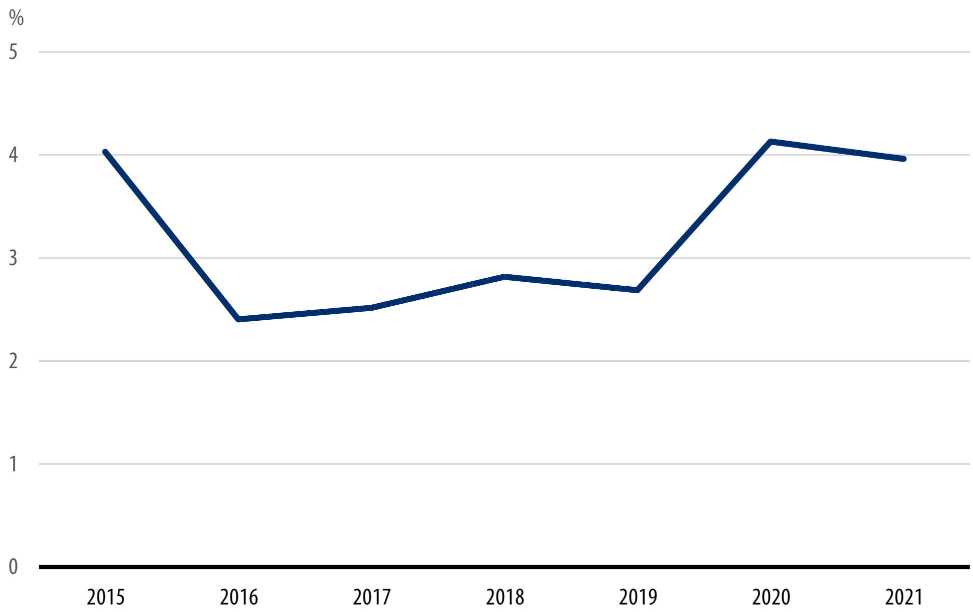
The Finnish ODA to SRHR is mainly comprised of support to the United Nations Population Fund (UNFPA); 70–80% of the total aid to SRHR goes to UNFPA (see Figure 12). UNFPA has an important role, as it holds the mandate to take action in the UN on population and SRHR-related matters. Finland, as a donor, has a say through its active dialogue in UNFPA's decision-making. Other supported non-governmental organisations, albeit more meagre in size, are the International Planned Parenthood Federation and the Family Federation of Finland.

Figure 12. Breakdown of population policies/programmes & Rreproductive health (SRHR)



Source: Figure created by the author using disbursements from OpenAid.fi

Figure 13. Share of SRHR disbursements in total ODA



Source: Figure created by the author using disbursements from OpenAid.fi

How could the OC be implemented in the future?

Globally, there is a need for a more significant push towards boosting sustainable development and demographic change while considering the effects of rising living standards on biodiversity. Conservative politics and economic crises pose challenges to demographic change, and the world regularly witnesses hindering or even reversing developments, particularly affecting women's empowerment, education, health, and sexual and reproductive rights.

In Finnish development policy, gender equality and women's and girls' rights, including SRHRs, have increasingly been prioritized. While they are implied to remain so, there is clear scope for improvement relative to other donors.

Despite Finland's relatively satisfactory past performance in increasing ODA and its shares in areas contributing to demographic change, there are challenges ahead regarding Finland's role and impact on global demographic change. Attaining a 0.7% share of ODA in GNI has been delayed to post-2026. There is an increasing need to ensure the political support of taxpayers for ODA and other relevant public expenditure. This could be done by directing more assistance to politically supported areas such as women's and girls' education or developing Finnish education exports to developing countries, not to mention improving understanding and effective communication to the public on what works in accelerating global demographic change. The research on the broad link between ODA and demographic change remains inconclusive (see e.g. Clements 2020), and there is a constant need to better understand aid effectiveness, which calls for more research funding in the future.

More effective, empowering, safer and more ethical technological innovations supportive of SRHR (e.g., technology and digital applications and tools[2]) would be of utmost importance. While funding to relevant areas of research and innovation has faced headwinds, this is where Finland, as a developed nation, could play an increasingly important role in ensuring rich biodiversity for future generations.

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6.6 Changing Our Measures of Economic Progress (Johanna Pakarinen, Statistics Finland)

Summary of the option for change (OC)

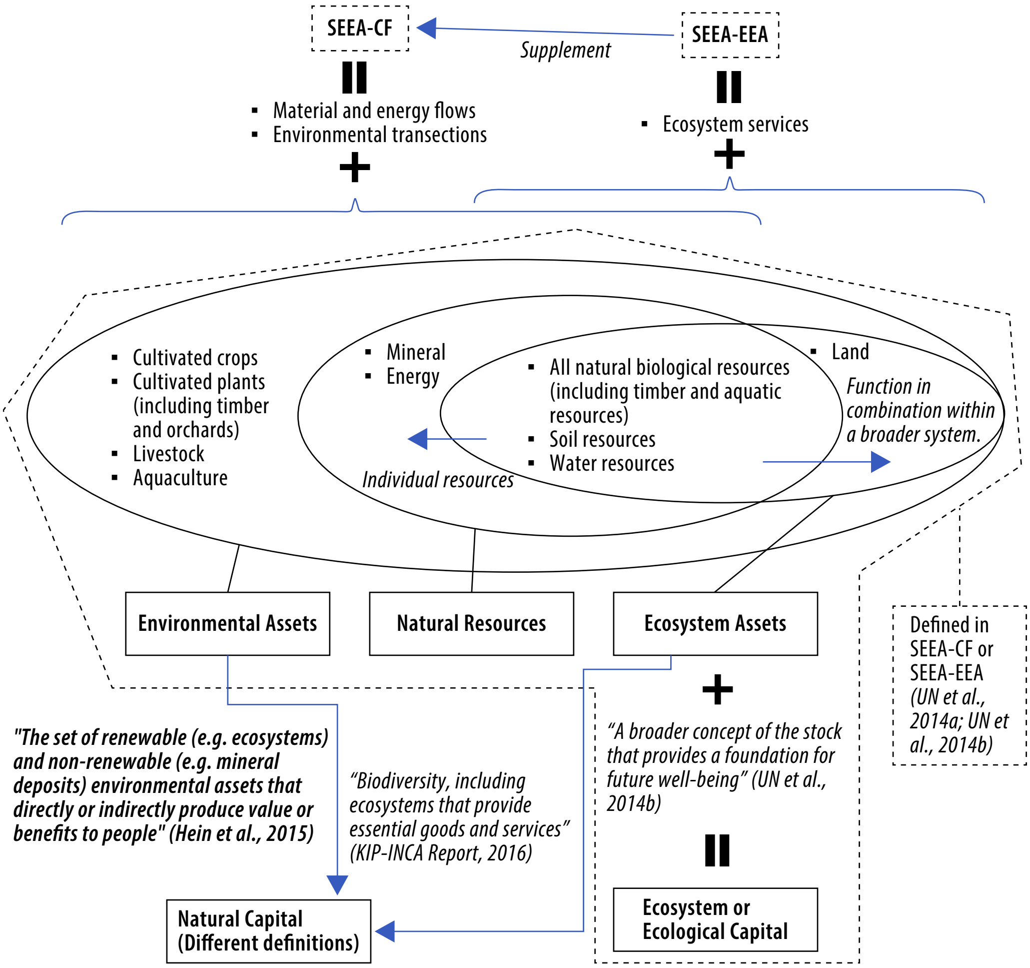
In the chapter "Changing our measures for economic progress", Dasgupta describes natural capital accounting as a "*necessary step towards the creation of inclusive wealth accounts*". Natural capital accounting will enable us to show the changes in natural capital over time and value of nature's services and integrate these into national accounting. According to Dasgupta, to make sustainable decisions across generations, standard economic measures need to be broadened to encompass all three types of capital: produced, human and natural. Traditionally, economic statistics mainly consider the first two capital types, with little or no weight given to natural capital factors, and this leads to biased growth and productivity indicators. Several other indicators have been developed to enhance or compliment national accounts, such as the Genuine Progress indicator, but the review focuses on natural capital accounting as a means of extending national accounting to the environment.

The key framework for natural capital accounting is the UN's System of Environmental and Economic Accounts (SEEA). Many countries, such as China and New Zealand, which are presented in the report, are working on incorporating natural capital accounts and flows of ecosystem services into their own frameworks. However, global development is still in the early stages and data needs and availability differ from country to country. What is needed to drive the work is international cooperation and standardization.

How the OC is currently implemented in Finland

The System of Environmental Economic Accounting (SEEA Figure 14) is the accepted international standard for environmental economic accounting, which brings together environmental and economic information. The two main parts of the SEEA are the central framework and ecosystem accounting. The SEEA Central Framework was first adopted by the UN in 2012 and SEEA Ecosystem Accounting in 2021.

Figure 14. The scope of the SEEA-CF, SEEA-EEA, and different terms related to environmental assets



Source: Lai et. Al (2018)

The SEEA Central Framework (CF) allows for the integration of environmental information with economic information in a single framework, while the SEEA Ecosystem Accounting (EA) considers how individual environmental assets interact as part of natural processes within a given spatial area. SEEA's parts and accounts are often interlinked with each other, and with the System of National Accounts (SNA). For example, forestry and related activities recorded in forest accounts (CF) can provide various ecosystem services (EA) and monetary flows recorded in the environmental goods and services sector (CF) and gross domestic product (SNA).

It should be noted that most of the SEEA accounts cannot be directly integrated into GDP. Rather, it is satellite system that utilizes the same concepts, structures, rules and principles as SNA. Thus, the data from the SEEA and SNA can be combined, enabling, for example, the analysis of emission and energy intensities by economic activity and often also by economic actor or how large a share of the monetary flows is related to environmental activities.

SEEA implementation in Finland is based the requirements of Regulation No (EU) 691/2011 on European environmental accounts. Currently, there are six accounts in regular production:

- environmental goods and services,
- environmental production expenditure accounts,
- environmental taxes,
- air emission accounts,
- physical energy flow accounts and
- economy-wide material flow accounts.

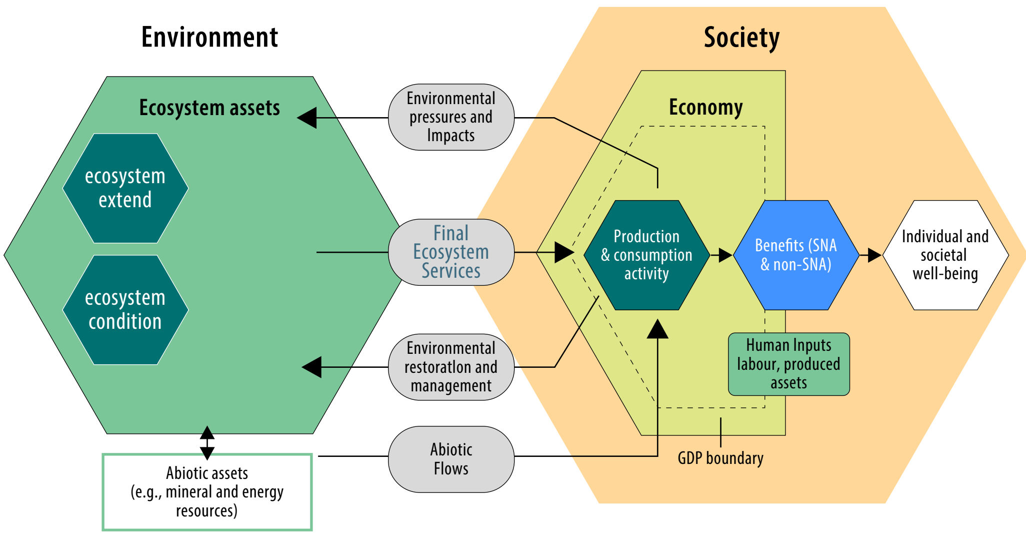
All the accounts mentioned above are produced and published annually by Statistics Finland as official statistics.

Additionally, the European Commission adopted a proposal to amend Regulation No (EU) 691/2011 on European environmental accounts in July 2022 (EUR-Lex, 2022). The Commission proposal is published in the EUR-Lex portal and will enter the ordinary legislative procedure in the European Parliament and the Council. The procedure is expected to last around two years. This proposed amendment will expand the mandatory set of environmental accounts by three new accounts:

- forest accounts,
- environmental subsidies and
- ecosystem accounting.

From the proposed new accounts, ecosystem accounting is the most highly anticipated and the most ambitious. The ecosystem accounts will cover the extent and condition of ecosystems and the flows of ecosystem services (Figure 15). The first reference year is proposed to be 2024, with reporting within 24 months of the end of the reference year. The ecosystem services accounts are to be compiled annually and ecosystem extent and condition accounts every three years. (EUR-Lex, 2022)

Figure 15. SEEA EA Conceptual Structure. Source: United Nations (2022)



The Finnish Environmental Institute, Natural Resources Institute and Statistics Finland have been active in developing ecosystem accounting for several years (SYKE, 2022). Natural capital accounting has been one driver for this work. Many pilot studies and accounts, such as a thematic account for biodiversity in forests, have been conducted; these are summarized in Table 5. However, the work has been limited to pilot studies and projects, as no clear mandate or resourcing is currently available to continue the development and initiate the production of regular statistics[3].

3 In addition to ecosystem accounting, the Finnish Ecosystem Observatory is currently being developed to gather ecosystem data from scattered sources (https://feosuomi.fi/en/feo-finnish-ecosystem-observatory/).

Table 5. Pilot accounts that have been developed in Finland

Account		Ecosystem Types / Ecosystem Services	Link to research
Accounts for ecosystem assets	Ecosystem extent account	**Marine**	
	Ecosystem condition account	**Marine**	
		Forest*	Hurskainen et al., 2021
	Ecosystem monetary asset account	**Marine**	Lai and Saikkonen, 2020
Accounts for ecosystem services	Ecosystem services supply and use table - physical terms	**Recreation**	Lankia et al., 2020
	Ecosystem services supply and use table - monetary terms	**Recreation**	Lankia et al., 2020
Thematic accounts		**Emissions of N and P to water**	In press: Wecktrom and Salminen
		Biodiversity in forests	https://github.com/PKullberg/EEA_and_BD/tree/master/ELITE_index
		Water abstraction and use	Salminen et al. 2018
		Water consumption and wastewater	Weckström et al. 2020
		Regional water asset accounts and water use accounts	In press: Salminen and Mattsson
		Urban pilot accounts for Helsinki, Tampere and Pirkkala	https://www.syke.fi/en-US/Research__Development/Research_and_development_projects/Projects/Developing_pilot_accounts_for_marine_freshwater_and_urban_ecosystems_and_packaging_materials_ENVECOPACK

Scale	State of development
National	Finished
Regional	Ongoing
Local	None ongoing or published

*Highlighed in the fact sheet

Source: MAIA (2022)

How the OC could be implemented in a more comprehensive way

Currently, the focus of official statistics in Finland is on compiling the obligatory statistics required by the EU regulation. However, these obligatory statistics are a result reached among the member countries, often based on factors such as data availability and available resources. The reporting levels are set to be feasible for all member states, even though on some occasions more detailed dissemination of data could better serve the decision makers. From the Finnish viewpoint, there may be SEEA accounts that could be of more use to us than the mandatory ones, and more detailed breakdowns and additional variables could be added if deemed necessary. All in all, the SEEA system contains many accounts that are not part of the EU regulation but could be produced if needed/wanted.

First and foremost, SEEA Ecosystem Accounting should be implemented at a detailed enough level to also support biodiversity monitoring. As already stated, SEEA EA itself is heavily interlinked with biodiversity, as there is an overlap in the measuring of ecosystems and biodiversity. In addition, many SEEA accounts can be used to measure biodiversity either directly or as a proxy. For a non-exhaustive list of applications, see Table 6.

Table 6. Linking SEEA accounts to biodiversity at levels other than ecosystems

Framework	Account	Aggregate	Relevance
SEEA EA	Extent	Extent of Ecosystems	Trends in the extent of ecosystems important for biodiversity can be used to infer implications for species and species loss. They also provide an insight into habitat loss, a key driver of biodiversity loss.
SEEA EA	Condition	Biotic characteristics	These [biotic characters in ecosystem condition accounts] can distinguish ecosystem assets in which biodiversity is more intact. For example, identifying areas of grassland with high values for species-based indicators or patches of forest with 'good' structural characteristics. They can also provide information on where biodiversity is threatened, based on trends of poor condition (e.g., invasive species abundance).

Framework	Account	Aggregate	Relevance
SEEA EA	Condition	Abiotic characteristics	These [abiotic characters in ecosystem condition accounts] can track where pressures on biodiversity may be manifesting (e.g., where pollutant concentrations are increasing). They can help highlight and quantify potential relationships between ecosystem degradation and species loss, including through the use of habitat-based biodiversity assessment techniques
SEEA EA	Services	Physical Supply and Use	Aggregates for provisioning services can identify where overexploitation of individual species is occurring (e.g., where sustainable yields are being exceeded). This can also include illegal use, such a poaching, where the sustainable yield may be zero.
SEEA Central Framework	Land Use & Land cover	Areas of biodiversity impacting or enhancing activities	Data on land use, land use change and land cover allow information on spatial biodiversity loss to be linked to different sectors and economic activities.
SEEA Central Framework	Emissions Accounts	Spatially disaggregated emission flows	Emission flows can identify where pollutant pressures on biodiversity are likely to manifest. These insights are enhanced by (potentially) linking to spatially disaggregated accounts.
SEEA Central Framework	Environmental Protection Expenditure	Expenditure on biodiversity conservation and enhancement	Where these financial transactions [of environmental protection expenditure on conservation and enhancement] can be linked to changes in ecosystem and species status or indicators of biodiversity at scale, they can have significant policy implications. In particular, they will be useful in understanding the ecological and economic benefits from public and private expenditure on the environment and biodiversity

Framework	Account	Aggregate	Relevance
SNA	Production and Consumption	Monetary transactions involving biodiversity-related goods and services	A number of monetary aggregates relevant to biodiversity exist in the SNA (e.g., provisioning services, wildlife tourism, recreational activities in nature). These aggregates can also be linked to the elements of biodiversity supporting their supply via the SEEA EA. They can additionally inform on the opportunity costs for biodiversity conservation (e.g., revenues foregone). Furthermore, they can inform on monetary trade-offs / opportunity costs associated with different management approaches for biodiversity.

Source: United Nations et al. (2021).

As the coverage of the SEEA accounts expands, it is important to have a clear mandate to produce the accounts. Compiling high-quality statistics requires long-term commitment and sufficient funding. The cross-statistical nature of SEEA requires constant communication and coordination amongst source data providers, researchers, compilers and data users. A suitable platform for the work is needed. In order to have efficient cooperation amongst the experts working with SEEA, the barriers to work, information sharing etc. between the different organizations involved should be made as low as possible.

Information needs

To build efficient monitoring frameworks for policies, there needs to be a careful consideration of what needs to be measured and how to obtain the necessary data. To do this properly, experts on metrics and indicators should already be involved during the process to assess whether the chosen indicators are feasible and cost-efficient to produce. For national strategies, particularly on forests, biodiversity, bioeconomy, recreational use and the circular economy, SEEA accounts could offer very much information, especially when combined with other economic and social data.

Sometimes, existing data may already be available for monitoring. One example of such an effort is the circular economy business indicator set (Statistics Finland, 2022), an indicator set compiled solely from pre-existing data from different statistics and piloted within SYKE's CircWaste project. On some occasions, data are not yet available and new indicators need to be developed. Especially in cases where suitable measures for monitoring the policies are not readily available, the development of the metrics and measurement of progress should also be considered in the total costs of the programmes.

There should also be consideration of what we want our handprint to be. Finnish know-how in environmental accounting has traditionally been in high demand. Finland has a strong track record in participation in the development of the SEEA system. The technical and methodological support of Finnish SEEA CF experts has been exported to over 15 countries globally. The work done in the projects of SYKE has been pioneering, and Finland is in a good position to be among the forerunners in the development and implementation of the framework. Being active in international forums will ensure that the statistical frameworks and requirements will be relevant to our national circumstances.

There are still many areas of ecosystem accounting that require further investigation. In addition to the methodological aspects, developments such as the automatization of workflows, classifications and terminology and valuation need to be carried out before commencing regular statistical production. In order to have usable statistics, the data need to be produced in a systematic manner and be comparable over time and between countries.

Additionally, integrating the indicators into the decision-making process is crucial. As Dasgupta noted, the GDP can be misleading if used as a proxy of well-being across generations. Some SEEA accounts have been in production for years, but their usage is scarce. It is necessary to ensure that the metrics are timely, understandable and easily available to users.

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6.7 Global Public Goods (Nina Tynkkynen, Åbo Akademi University)

Summary of the option for change (OC)

The Dasgupta Review leans on the concept of global public goods (GPGs) when referring to such common resources that benefit several groups of countries and the majority of the global population and meet the needs of the present generation without discriminating against any population group or future generations (Kaul et al. 1999). Such public goods essentially encompass the goods provided by the natural environment. A distinction between final and intermediate global public goods can be made: restored or preserved biodiversity and the international regime that helps to achieve the final good, respectively (Kaul et al. 1999, p. 13).

The GPG concept has many similarities with the term 'the commons' (see Brando et al. 2019 for a comparison). While commons theories (e.g., Ostrom 1990) generally emphasize non-hierarchical and lower governance levels and polycentric solutions for the governance of particular common resources, GPG theory mainly focuses on the national and higher levels, putting states and international communities and institutions at the centre (Kaul et al. 1999).

Dasgupta discusses two cases of GPGs related to biodiversity: those provided by the world oceans beyond the 200-mile exclusive economic zones, and rainforests that fall within national jurisdictions (Abridged Version p. 42). The main option for change is set in the promotion of effective institutions as the foundation of safeguarding these GPGs. Institutions need to be planned to be fit for purpose (p. 76).

As a common property resource (Hardin 1968) beyond national jurisdictions, the oceans can be subject to international control, such as global taxation or, for example, the regulation of fisheries and transportation. For sovereignty reasons, other measures need to be taken to preserve the world's rainforests. According to Dasgupta, the global community should pay the nations harbouring the rainforests to preserve them. There is room for institutional development regarding how this could be done.

Global public goods and Finland

Finland essentially contributes to intermediate GPGs: the regimes and institutions that aim to protect the GPGs. International biodiversity policy is carried out in the framework of the Convention on Biological Diversity (CBD, 1992) and the Conferences of Parties to the Convention. The main tools for implementing the CBD consist of National Biodiversity Strategies and Action Plans; thus, the final biodiversity GPGs mentioned in the Dasgupta Review, i.e., those provided by the oceans and rainforests, mostly fall outside the scope of these tools for Finland, which actively participates in these policies (Sääksjärvi 2020).

In addition to oceans and rainforests, other biodiversity-related GPGs are also of relevance to Finland. These include Arctic ecosystems and biodiversity, including many globally significant populations, e.g., of migratory birds. Furthermore, the circumboreal forests contain circa one-third of all terrestrial carbon, which is comparable to tropical forests (Bradshaw and Warkentin 2015). The Arctic biodiversity includes a multitude of poorly known species that collectively provide the foundation for food webs and ecosystems (CAFF 2013). Climate change is driving biodiversity loss, as native species are disappearing and/or invasive species are expanding their habitats and spreading further north. The combined effects of climate change and land use are threatening many ecosystems, such as the protected areas in Lapland, which cover about 30% of the surface area.

Strategic measures lifted up in Finland's updated strategy for Arctic Policy (2021) underline the deployment of nature-based solutions, the rehabilitation and restoration of degraded ecosystems, the development of cooperation mechanisms for the management and use of natural resources and protected areas together with the Sámi, and the promotion of international cooperation to establish a comprehensive network of marine protected areas in the Arctic Ocean. In addition, the efficient control of invasive alien species and building up the knowledge base of invasive alien species is mentioned.

Finally, consumption and production patterns (Chapter 6.2 of this publication), as well as supply chains, trade and pricing (ch. 6.3 and 6.4) at individual, commercial and governmental levels have a direct impact on GPGs. The EU import ban on Brazilian beef, forest certificates, or certificates for more sustainable use of marine resources (e.g., dolphin-safe tuna) are examples of measures to address GPGs.

How the OC could be implemented in a more comprehensive way

Dasgupta proposes the creation of a global insurance scheme against ecological degradation. Many promises have made in the ongoing negotiations concerning the new global framework for biodiversity protection, which is to establish the key measurable targets to protect and restore biodiversity in a way that links biodiversity, the economy and society together in a positive manner (see Ch. 1). One suggestion is a "Global Marshall Plan for protecting the biosphere" (p. 42), which would enable the use of the revenue collected from one GPG (e.g., oceans) to cover part of the international payment for the protection of some other GPG (e.g., rainforests). Synergies with climate policy (the new Loss and Damage Fund for Vulnerable Countries) could be sought. Furthermore, the proposed Global Ocean Treaty presents an opportunity to fill gaps in biodiversity monitoring and conservation. The instrument on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (BBNJ) under the UN Convention on the Law of the Sea will also increase UN regulation in the Arctic Ocean.

Finland and other Nordic countries have been portrayed as environmental leaders (Jordan & Adelle 2013) and as forerunners of new forms of environmental governance combining public and private sectors in an effective manner (Eckerberg & Joas 2004). The long tradition of Nordic cooperation is a strength that can be utilized both at the EU and global levels. However, in recent years, the leader image has been lost and should be revisited, for instance, by actively advocating more stringent international provisions in biodiversity policy. Together with the other Nordic countries, Finland could, for example, take a major role in strengthening the EU Arctic policy. A major challenge regarding Arctic cooperation is of course Russia's engagement. Even though cooperation with the Russian Federation has currently halted, the cooperation needs to continue at some point, as Russia is a key player when it comes to Arctic biodiversity. Leaning on the long expertise in green diplomacy gained in Baltic Sea cooperation, Finland may play a role in mitigating environmental policy tensions. Moreover, Finnish long data series, e.g., regarding marine changes, can serve as valuable predictors of oceanic changes worldwide.

Finally, indigenous rights should be promoted alongside biodiversity protection; Finland's development policy based firmly on the upholding of human rights is in a key role and should be continued with regard to biodiversity GPGs.

Information needs

The academic literature raises two issues that need to be critically addressed regarding the management of GPGs (e.g. Kaul & Blondin 2016). First, it is important that the governance requirements that GPGs pose are further researched. What kind of governance and what kind of institutions would best fit the purpose? How could, for instance, the suggested Global Marshall Plan be implemented and adjusted with similar climate policy needs, and where can synergies be found? More knowledge is needed, for example, about a biodiversity footprint that would take into account externalized effects and biodiversity outsourcing. Second, GPGs need to be analysed in the light of current shifts in international power relations, including the increase in multipolarity, insecurities in the power balance between the state and non-state and geopolitical tensions. Particularly regarding Arctic cooperation, ways to act without Russia's engagement (or with it, at later stage) need to be researched. Moreover, knowledge and education regarding the dynamics and interdependency of local, regional and global levels of biodiversity are essential.

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6.8 The Global Financial System (Hanna Silvola, Hanken School of Economics)

Summary of the option for change (OC)

The Dasgupta Review criticizes the current practice of measuring the economy with gross domestic product (GDP), considering it too one-sided a measure that does not take Nature into account – or worse, it is taken as free of charge. The Dasgupta Review suggests the following options for change: (i) ensure that our demands on Nature do not exceed its supply and that we increase Nature's supply relative to its current level; (ii) change our measures of economic success to help to guide us on a more sustainable path; and (iii) transform our institutions and systems – in particular, our financial and educational systems – to enable these changes and sustain them for future generations.

How the OC is currently implemented in Finland

The global financial system has recognized and understood biodiversity as a significant feature of life. The financial sector has focused on climate risks for years. It has now started to understand that climate change cannot be solved without taking into account nature, which is rapidly becoming impoverished. The World Economic Forum estimates (2020) that more than half of global GDP is strongly or fairly strongly dependent on diverse and prosperous nature and the ecosystem services it provides. This potential financial instability means that central banks and financial supervisors need to better assess the risks associated with the loss of biodiversity (NGFS, 2022).

In Finland, in a survey conducted by FIBS in 2019, more than 90% of the company managers considered climate change as significantly affecting their business, while only 8% raised biodiversity as a priority area of responsibility work. In a few years, the situation has changed, and according to FIBS's latest survey in 2021, already 41% of company managers considered biodiversity to be an important or very important focus of responsibility work. The front-runners have even linked their bank loans or bonds to biodiversity indicators. As the Dasgupta Review also reports, the global progress to assess and measure biodiversity risks and benefits is not yet standardized and does not provide useful tools and measuring systems to solve the challenge.

The European Union has taken a significant role in shaping the regulatory landscape of the businesses and financial sector. For example, the forthcoming Corporate Sustainability Reporting Directive (CSRD) will require businesses to disclose their biodiversity information from 2024 onwards. The new law will have a specific standard (ESRS E4) on biodiversity and ecosystems which requires companies to disclose information on how they integrate biodiversity into their strategy, business implementation process and performance measures. This is an important step forwards: it has been estimated that 50,000 large companies in the EU will fall within the scope of this disclosure requirement during 2024–2026. According to various estimates, the scope of the reporting requirement includes around 700–1 500 companies in Finland.

In addition to the CSRD requirement, the EU requires companies to also report on their taxonomy eligibility (from 2021) and alignment (from 2022). Biodiversity is one of the six environmental objectives in defining the green taxonomy. The taxonomy criteria for biodiversity will be completed in 2023. The EU taxonomy is an important tool for financial markets to define which investment targets are green and sustainable, and it aims to help investors to allocate their financing to green activities. Investors need to apply the taxonomy criteria in defining funds as dark green (Taxonomy's Article 9), light green (Article 8) and other (Article 6). This aims to help all investors, from institutional investors (e.g., pension funds, professionally managed funds) to private individuals, to allocate their financial resources to green investments where biodiversity is one of the key objects.

Beyond the EU, on the global level, the ISSB is developing sustainability standards to be implemented in all companies that now apply International Financial Reporting Standards (IFRS). This will apply to more than 160 countries globally.

In addition, several voluntary initiatives are under development. These will offer concrete tools for businesses to provide information on their biodiversity to financial markets, including the following:

- The Taskforce on Nature-Related Financial Disclosures (TNFD)
- GRI (Global Reporting Initiative) – updates the current biodiversity standard
- CDP (Climate Disclosure Project) – expands its survey to also cover biodiversity
- The Science-Based Targets for Nature (SBTN) model

Thus, standardized assessment and measurement systems, as well as public disclosures, will also be available to Finnish businesses and financial institutions in the coming years. Finnish organizations have not started to develop their own measuring systems or tools, but the actors in the field are waiting for the global frameworks to be completed.

Currently, the valuation of biodiversity risks, benefits and opportunities is very difficult and exceptional because the tools are mostly lacking. Therefore, it is meaningful for companies to follow the next steps:

1. identify the risks, benefits and opportunities related to biodiversity,
2. quantify them,
3. estimate the financial effects and
4. use this information for better decision-making.

The leading companies have started to identify their biodiversity risks, although useful measurement tools are still under development. Due to the extensive global standardization work, it can be assumed that quantitative and even monetary metrics will be disclosed in the coming years.

How the OC could be implemented in a more comprehensive way

Even though the EU is already implementing massive regulation through its Green Deal and Sustainable Finance Action plan in financial markets and businesses, there are some potential ways in which biodiversity aspects could be even more comprehensively implemented in Finland:

1. Integration of biodiversity into the fiduciary duties of institutional investors and asset managers. The Dasgupta Review suggest that integrating the protection of biodiversity with the fiduciary duties of institutional investors and asset managers would be a way to ensure that their investment policies account for natural capital. Fiduciary duties refer to the legal responsibilities of these organizations that currently relate to making a profit and safeguarding

the financial value of assets. In Finland, institutional investors, such as pension funds, can voluntarily pay attention to biodiversity issues, among other ESG risks and opportunities, but this cannot be in conflict with their fiduciary duties. As biodiversity often goes hand in hand with climate change and is connected with social and governance issues, sustainability issues on a larger scale could be integrated with the fiduciary duties of institutional investors and asset managers. France, one of the leading countries in responsible investing, has already enacted national legislation for asset managers on the biodiversity effects of investments (PRI, 2018).

2. Assessment of the biodiversity risks, benefits and opportunities to be required in applying for public funding (e.g., Finnvera, Business Finland), because the private financial sector already does so at least to some extent.
3. Assessment of the biodiversity risks, benefits and opportunities to be required from public procurements among the other sustainability aspects.
4. Circular business models should be supported and required by prioritizing circular economy policies that have significant overlaps with climate and biodiversity. Sitra (2022) estimates that the change towards a circular economy could halt biodiversity loss in Finland.
5. Cross-disciplinary research on the association between biodiversity and financial markets, especially from the Finnish perspective. Recent studies quite widely demonstrate that ESG factors have financial relevance (e.g., Friede et al., 2015), but we need more scientific evidence on the financial materiality of biodiversity. Financial decisions are as good/bad as the data that we can apply in making these decisions. Therefore, scientific, transparent and reliable data on this association is a requirement for better reasoned decisions.
6. Integration of biodiversity aspects into education on all educational levels. Educational and research institutions could be better incentivized to integrate environmental (or even widely sustainable) viewpoints in their teaching curricula. This does not only apply to business studies, but to all disciplines and schools. One option would be to do this through funding models.
7. The creation of a shared platform from where different actors (whoever is interested) would find science-based information, tools and supporting materials to apply and integrate biodiversity aspects in their activities (either in business development, funding decisions or research activities) is needed. In particular, small and medium-sized companies (SMEs) and organizations need support, concrete processes and tools for evaluating biodiversity risks, benefits and opportunities. The demand for this information for SMEs is increasing due to their supply chains. A national-level information sharing unit that offers appropriate services especially to SMEs would be welcome.

Information needs

Regarding information needs, the question is not only about data and indicators, but more wide-spread knowledge of biodiversity as a phenomenon and its influence on financial decision-making. The last three points of the previous chapter already refer to the information needs.

We need to make sure that individuals in different educational institutions become aware of biodiversity issues during their studies, independent of their institution. The information needs of education must be taken into account in all fields and levels of education.

Information needs are even greater in companies, in the public sector and in other institutions where professionals need to update their knowledge on biodiversity-related issues. Currently, industry-leading companies and financial institutions organize customized sustainable development training for their key personnel. The loss of nature is identified as a growing theme in these training programmes. Companies are willing to invest more in this theme and they are ready to learn more, but there are few available speakers on the connection between biodiversity and the economy. In any case, continuing education is needed.

The information to be taught must be based on scientific evidence, and multidisciplinary research is therefore essential. One very central shortcoming in the Finnish research environment is the lack of an interdisciplinary approach regarding the association between biodiversity and the economy. The economic dependencies of nature loss have been understood, but their economic consequences have still been estimated very little, even at the international level. One interesting benchmark would be the Centre for the Understanding of Sustainable Prosperity (CUSP), which is a multidisciplinary research centre that aims to understand the economic, social and political dimensions of sustainable prosperity. The research centre is a collaboration between about ten different universities. As a small country, Finland should encourage cooperation and integrate its limited resources when studying the economy from an environmental perspective. Strong interdisciplinary research would be needed in Finland. It should combine economics and natural science, especially in research on themes related to climate and nature.

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6.9 Empowered Citizenship (Simo Kyllönen, University of Helsinki)

Summary of the option for change

The Dasgupta Review underscores the role of empowered and motivated citizens in bringing about the systemic changes proposed in the Review. The essential role of citizens is understood in several ways. Firstly, citizens can act as *active consumers* who insist "that financiers invest our money sustainably, that firms disclose environmental conditions along their supply chains (product labelling is a partial method for doing that)" (494), and who, finally, even boycott products that do not meet their standards. Secondly, Chapter 6 of the Review also discusses the role of citizens as part of civil society and communities whose engagement is seen as essential for the effective institutions of systemic changes. Part of the effectiveness is explained by civic activities that help create mutual trust and joint action among members of society. This highlights citizens' civic virtues and the democratic institutions (including education) that empower citizens as (trustworthy) political actors.

In addition, the Review mentions two main obstacles to citizen empowerment in the protection of biodiversity (BD). One obstacle is our detachment from Nature due to "growing urbanisation, the profusion of technology, and reduced access to green spaces" (494). According to the Review, this has not only meant a loss of our personal well-being, but may also partly explain our decreased motivation to act as citizens who "make informed choices and demand change" (p. 494). The second obstacle is more implicit and is related to contemporary, largely individualistic understanding of citizenship, which hinders required collective action and the needed institutional change.

To address these obstacles, citizen empowerment should entail, first, increasing citizens' interaction and sense of connectedness with nature, e.g., by providing access to green spaces (Figure 16). Second, there is a need for more social and collective understanding of citizenship, in which citizens understand their own acts as part of collective consumption patterns and conditioned by social and economic structures, the change of which requires large-scale collective and public activity, both as consumers and as citizens.

How the OC is currently implemented in Finland

Regarding access to green spaces and the connectedness of Finns with nature, surveys indicate that most Finns use natural areas for recreational outdoor activities. In addition, almost every second Finn enjoys observing nature (for example, identifying plants or watching wild animals), and more than every second is interested in viewing nature's sights (for example, rapids, landscapes, vantage points and fjords). Moreover, almost every fourth Finn has a birding hobby (Neuvonen et al. 2022). There is also growing evidence of the well-being and health effects of nature-based recreation in Finland (Korpela et al. 2014, 2010).

However, it is less evident how well these active contacts with natural areas increase the connectedness of Finns with Nature and their motivation to act on more large-scale changes to protect biodiversity. While taking care of the natural environment or restoring it to its natural state (e.g., meadows) now excites more Finns than 10 years ago, the number is still quite limited: in 2020, 4% reported doing so. On the other hand, in urban areas, where the population is increasing rapidly (e.g., the Helsinki Metropolitan area) and where the pressure to reduce the amounts of urban woodlands and forests is therefore the strongest, plans to construct on existing green areas have provoked conflicts and created civic movements among local residents to oppose the plans. Studies also indicate that although green areas seem to be important to all income classes (Tyrväinen et al. 2007), allowing construction on existing green areas is easier to push through in lower income areas in municipal land-use and policy processes than in better-off areas. Thus, existing planning policies appear to have unequal distributional effects on the possibilities to enjoy green spaces and nature-based recreation.

With respect to the need for more collective and social understanding of citizenship, the campaigns of governmental authorities (in the EU and in Finland) still tend to focus on motivating citizens to make individual lifestyle changes as consumers rather than act together for the required changes (Vihersalo 2017). However, and importantly to overcome the Review's obstacle of understanding citizenship too individualistically, recent empirical studies on environmental activism in Finland (e.g., Extinction Rebellion, The Fridays for Future movement) show how activists often connect changes in their personal behaviour and lifestyle to the demands for global justice and requirements for political action from decision-makers (Huttunen & Ahlberg 2021).

Researchers have connected activists' demands to a broader understanding of environmental or green citizenship that is essentially about regarding one's activity as a part of a wider global and intergenerational community (e.g., Dobson & Bell 2006, Wood and Kallio 2019). The main idea is that in today's interconnected world, every economic action has environmental implications, which through complex production, logistics and consumption chains are channelled around the world and have effects on how resources and waste are distributed globally and between generations over time. Environmental citizenship is thus essentially about reflecting individual and collective choices in terms of the just distribution of environmental resources and impacts (e.g., measured by the ecological footprint).

However, the main challenge in Finland – like in most societies – is to develop the decision-making institutions to be more sensitive to the broader understandings of environmental citizenship (see more below). More sensitive and inclusive forms of citizen participation may also be important in the (re)creation of mutual trust and critical debate among citizens. The level of political trust in Finland is usually taken to be very high when compared to other countries (OECD 2021). Nevertheless, recent surveys indicate that this high level of trust may be eroding (Jämsén et al. 2022, Setälä et al. 2023). Surveys also show that Finnish citizens have very low confidence that Finland's political system allows them to have a say in government decision-making (OECD 2021). Approximately one-third of citizens have hardly any participation in influencing decision-making in Finland.

Finland's decision-makers and public officials, for their part, do not have confidence in the capacity of citizens to engage in discussions on complex issues (Jämsén et al. 2022). These results seem to indicate that there is an increasing gap between political elites – experts, bureaucrats and elected decision-makers – and citizens. Especially when technically complex issues, such as the loss of biodiversity, become politically divisive, partisan commitments and material interests can have an effect on people's judgements about the trustworthiness of policy-makers, experts and other citizens (MacKenzie, Kyllönen & Setälä 2023). This development is against the Review's view about the important role mutual trust plays in the effective governance of biodiversity.

How the OC could be implemented in a more comprehensive way

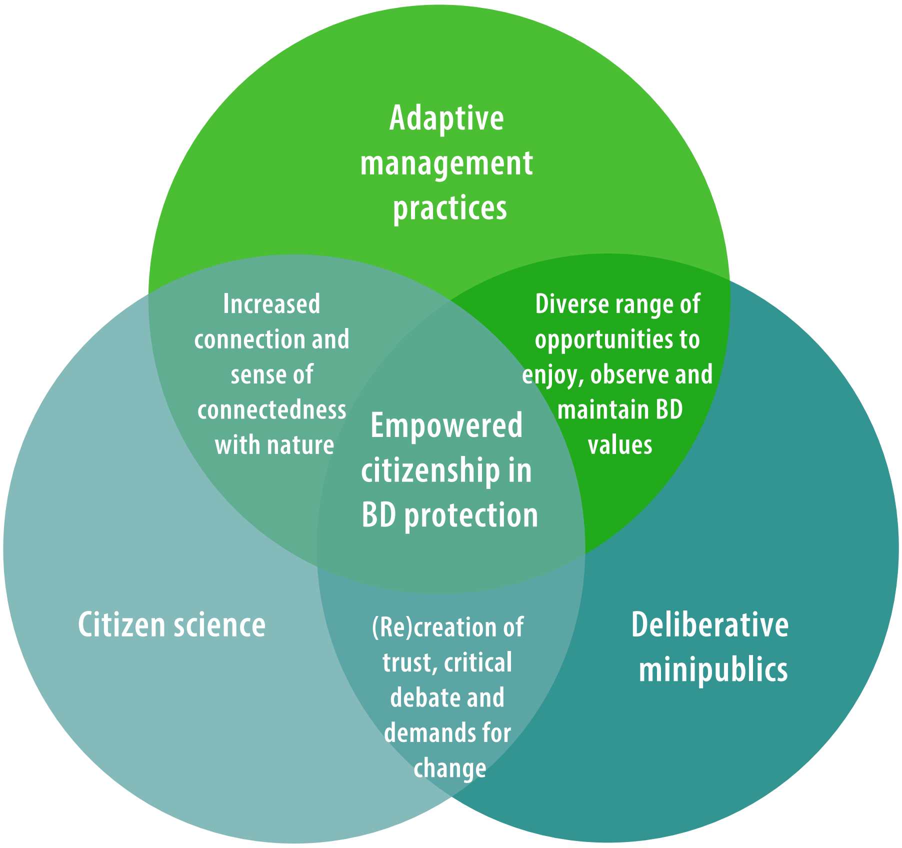
The green citizenship literature and recent surveys highlight how citizenship practices and activities should be understood in multiple ways (Jämsén et al. 2022). Bedessem et al. (2022) conclude that a genuinely representative and inclusive governance of biodiversity should include a diverse range of opportunities to participate. In the land use planning and management of green spaces, this could mean a shift towards ***more adaptive management practices in which citizens are involved in the continuous process of (re-) design and maintenance of green space***s and in which their local knowledge, experiences and emotions are acknowledged (Suomalainen, Tahvonen & Kahiluoto 2022).

In biodiversity-related research, ***citizen science*** – "the non-professional involvement of volunteers in the scientific process" (European Commission 2020) – has been particularly popular, as it enables the collection of data that the research would otherwise not have been able to obtain. Moreover, easily accessible mobile phone apps, such as iNaturalist.laji.fi, make it easy to report sightings of species and upload observations to databases, such as the Finnish Biodiversity Information Facility, which includes a significant amount of data collected by ordinary citizens.

However, an increasing number of studies also suggest that citizen involvement in biodiversity research and planning can also improve participants' knowledge and motivation in relation to biodiversity and their connection to nature (Aivelo & Huovelin 2020, Peter et al. 2021). Several recent studies have indicated that what matters is not only to be in contact with nature but to have a certain sense of *connectedness* with nature (The Dasgupta Review Chapter 11.6, Mackay & Schmitt 2019, Richardson et al. 2020). The feeling of being connected to nature guides what in their natural surroundings people focus their attention on and what emotions they connect to their experience of nature. Studies suggest that even "simple nature activities", such as watching or photographing wildlife, can significantly contribute to people's pro-nature behaviour when these activities at the same time enhance people's connectedness with nature, i.e., involve their "physical senses of sight, sound, smell, and touch" (Richardson et al. 2020).

Well-designed citizen involvement thus has a potential to increase citizens' awareness of biodiversity and connectedness with nature, and finally, to motivate them to act on protecting biodiversity. However, one challenge to enhance changes in knowledge, attitudes and behaviour more widely among citizens is the tendency of these participatory processes to mainly attract citizens who already have pro-environmental attitudes and motivations. In recent years, there has been a proliferation of ***deliberative minipublics*** on environmental issues, and their use is partly motivated by the aim of making participation more representative. The random invitation processes that are used to populate minipublics are designed to help ensure representativeness and that a plurality of voices and views are heard in these processes, and those who are usually politically passive may be encouraged to participate (Setälä and Smith 2018). In this way, by gathering participants from all socio-economic groups and by facilitating learning and common understanding among them, avenues may be provided for maintaining trust as well as possibilities for critique and demands for change (MacKenzie, Kyllönen & Setälä, 2023).

Figure 16. Multiple ways to empower citizens in the protection of biodiversity.



Information needs

While there is growing evidence of how the involvement of citizens can empower them to act on protecting biodiversity, more research is needed to find the feasible ways to do this in diverse contexts. The main challenge is to design the management and decision-making processes so that they are sufficiently sensitive to recognise the diversity in citizen's expectations and capacities regarding participation. Modifying current processes of urban planning to allow more citizen involvement in the maintenance of green spaces requires more studies on the potential involvement practices. More information is also needed on how to increase the sense of connectedness in citizens' nature activities and how this is related to their pro-biodiversity behaviour. Finally, the use of innovative tools of citizen involvement, such as minipublics, is still in its infancy in Finland, especially in complex biodiversity issues. More case studies are needed on how new tools and more diverse opportunities to engage citizens contribute to pro-biodiversity actions, especially at the collective level.

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6.10 Education and biodiversity (Niina Mykrä, University of Jyväskylä)

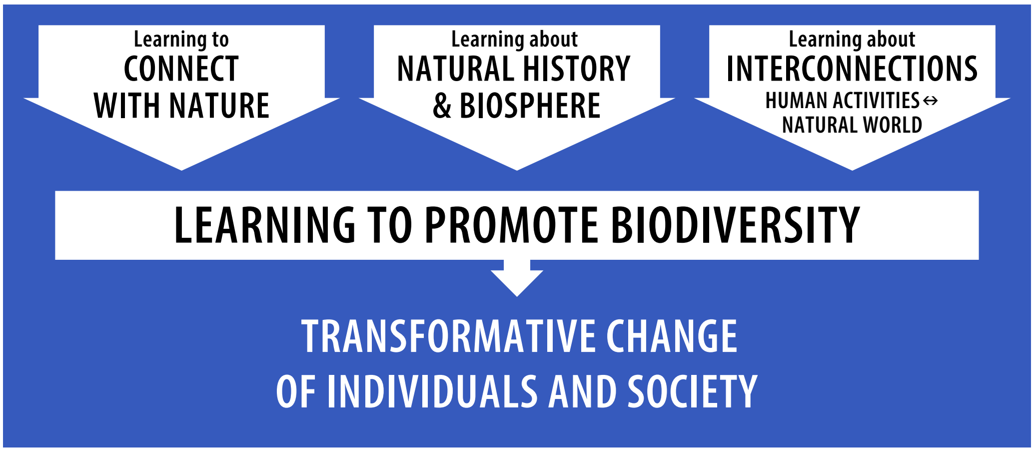
Finnish Institute for Educational Research, University of Jyväskylä

Summary of the option for change (OC)

The Dasgupta Review talks about education as human capital that has a measurable value to the individuals who acquire it, but also to society at large. Education is an intangible and non-alienable asset that has consequences ranging from the birth rate to well-being and awareness. Concerning biodiversity, the options for change lie in learning to connect with nature, learning about natural history and learning about processes in nature. Well-being can be nourished by outdoor education and experiential learning. The Review recommends focusing on local issues and locally relevant broader issues, emphasising the role of communities and civil society in the economics of biodiversity. According to the Review, nature studies, and especially connecting with nature, should be included in education from the earliest stages to the tertiary level.

Even though described as one foundation on which to rebuild our engagement with Nature and management of natural assets, the role of education remains somewhat unorganized in the Dasgupta Review. To conclude: Biodiversity has been declining at an alarming rate in recent years. If we want the future to be sustainable, we need a transformative change of individuals and society. To change, we must learn, and to learn, we must change. Biodiversity as an educational matter has three facets (Figure 17): 1) learning to connect with nature, 2) learning about natural history and the biosphere, and 3) learning about complex and multiscale interconnections between human activities and the natural world, both locally and globally. The last of these has minor emphasis in the Review, although, according to recent research on sustainability, it has a crucial role (Bianchi 2020).

Figure 17. Education and biodiversity



Education and biodiversity in the Finnish context

Most Finns consider nature important to themselves, although there is a wide range of different kinds of relationships with nature (Kantar TNS 2021). However, the relationships are changing (Haverinen et al. 2018). Connecting with nature has been a widely promoted goal in Finnish educational curricula (e.g., SYKE 2018). In addition, natural history has also had an important role in education: understanding about nature has helped to protect and sustain livelihoods in northern conditions, and the Christian idea of guarding and protecting nature has had a strong effect on early educational practices in Finland (Pihkala 2011). The third facet, learning about complex interconnections, requires transdisciplinary thinking and awareness of the cultural aspects of biodiversity loss. In this field, Finnish education still has much to improve: in everyday school practice, biodiversity should be more closely connected to activities such as school meals (also Ch 6.2) and different disciplines such as social studies. The recent European sustainability competence framework GreenComp (Bianchi et al. 2022) offers viewpoints that can lead the way forward: it describes the knowledge, skills and attitudes needed with four competence areas: sustainability values, complexity, envisioning the future and acting for sustainability. Educational policy in the EU and Finland has adopted GreenComp as one key tool to lead the way forward.

Environmental policies and biodiversity education

Biodiversity education is embedded in Finnish environmental policies. For example, the new Nature Conservation Act (2022) incorporates education more stringently than the previous one: National and local administration should promote environmental education to safeguard biodiversity. The process for a new national Biodiversity Strategy is ongoing, but in the current Biodiversity Action Plan of Finland, "Communication and education" is already one of the cross-cutting issues. The plan comprises four actions: the communication of biodiversity-related issues, further education for teachers, including sustainable development and biodiversity in curricula and collaboration in the environmental education sector. According to the assessment of the Biodiversity Working Group, the first three actions have been completed, but the last needs boosting.

Agenda 2030 is one of the main tools for implementing environmental policies in Finland. The state of sustainable development is monitored by indicators, which include biodiversity (indicator basket State of nature and the environment) and education (indicator basket Education and development of competence). However, education is not mentioned in the sections on biodiversity and biodiversity is not mentioned in the sections on education.

Educational policies

Explicit statements regarding ecological sustainability or biodiversity are rare in top-level *educational policy* documents (Mykrä 2021). For example, Strategy 2030 of the Ministry of Education and Culture (2019) does not include biodiversity and refers to sustainable development indicators for the sector, which mention no actions for ecological sustainability either (Prime Minister's Office 2022). Moreover, neither the vision nor the mission of the Finnish National Agency for Education includes ecological sustainability. Even the sustainable development policy for achieving the goals of Agenda 2030 (Ministry of Education and Culture 2020) states that "The special responsibility of the Ministry's administrative branch lies in the promotion of goals related to social sustainability" – it mentions climate change and the decline in biodiversity as two of the most severe problems, but does not introduce any educational actions to tackle them.

The Education Policy Report of the Government (2021) mentions biodiversity loss as one of the threats to education. It also tells that in recent years, according to PISA studies, the drop in the level of skills of 15-year-olds in natural sciences has been significant in Finland. The Education Policy Report sets a goal of "building a sustainable operating model where the footprint of human action (negative effects) could be turned into positive impacts, or a handprint." Only technical solutions to environmental crises are introduced.

Curricula and biodiversity

Sustainability is a pervasive principle in the curricula for general education (National Core Curriculum for Basic Education 2014; National Core Curriculum for General Upper Secondary Education 2019). Connecting with nature is an important topic in lower grades and learning about ecosystems is included through general education. The curriculum for basic education states that material choices and operating methods that lead to biodiversity loss should be replaced by sustainable ones. Environmental studies, biology and geography include learning contents on biodiversity. In the local basic school curricula of lower stages, connecting with nature is emphasised. In higher grades, the impact of human activities on nature are more closely studied. The curriculum for general upper secondary education introduces biodiversity in the sections "Underlying values" and "Transversal competences". It is included in the syllabi of biology and geography, and even in language studies and worldview studies.

In vocational education and training (VET), the promotion of sustainable development is one unit of the learning outcomes (1 cp/180) (Finnish National Agency for Education 2022a). Biodiversity is not mentioned, but it is included in the appendix of underlying values of the curriculum (Finnish National Agency for Education 2022b). In the qualification requirements for VET, whether biodiversity issues are included depends on the discipline. There are qualification-specific units that include biodiversity, such as "Vocational qualification in Natural and Environmental Protection" and "Management of commercial forests", in which one competence requirement is taking biodiversity into account.

In higher education, biodiversity is one area of studies and research. Universities of applied sciences declare in their mutual programme for sustainable development and responsibility that together with their graduates they are an important part of the solution in the struggle to preserve biodiversity (Arene 2020). In the universities, mutual theses on sustainable development and responsibility include a goal to take concrete measures to foster biodiversity and bring the importance of biodiversity to the societal debate, decision-making and activities (UNIFI 2020).

Non-governmental organisations promoting biodiversity education

Several non-governmental organisations (NGOs) promote biodiversity education in Finland. Two of these, the Finnish Association of Nature and Environment Schools (LYKKY) and FEE Suomi, are focused on working with schools and educators. In addition, for example, the associations Ulko-opet, WWF Finland, Suomen luonnonsuojeluliitto, Luonto-liitto and Natur och Miljö include biodiversity education in their activities.

Biodiversity and connecting with nature are among the main goals of LYKKY (luontokoulut.fi). It coordinates the LYKE network, which offers nature school days to school groups and provides support to teachers. About 1,000 groups and over 200,000 pupils with their teachers attendnature school days in 60 centres around Finland annually. In addition to this, centres offer about 140 training sessions annually for teachers. LYKKY also coordinates the outdoor learning event ULOS-UT-OUT and the MAPPA.fi service (80,000 different users per year), which collects together nature education materials (over 1 500 materials), services and events of different organisations (over 300 different producers of materials or services). One of the ongoing biodiversity projects of LYKKY is "Citizen Science for School Education: From Nature Observation to Knowledge of Ecosystems". The Finnish Biodiversity Information Facility is a partner in this project.

FEE Suomi coordinates the Eco School programme in Finland (vihrealippu.fi). It is the world's largest sustainable programme within the educational sector. In Finland, 95,000 children or young people and 11,000 teachers are involved in the programme. One of the nine themes of eco schools is biodiversity. FEE Suomi has published open biodiversity guides for early childhood education and basic education. In addition to this, FEE Suomi coordinates a round table for environmental education, publishes the journal Ympäristökasvatus (Environmental education) and prepares a newsletter, all of which also promote biodiversity issues.

A group of teachers has established an association for outdoor teaching (Ulko-opet ry). The teachers offer peer support through meetings and organise training sessions. The focus of the association is outdoor teaching, and biodiversity is one part of this. WWF, Suomen luonnonsuojeluliitto, Luonto-liitto and Natur och Miljö offer information, school visits, training and/or materials concerning biodiversity.

How the OC could be implemented in a more comprehensive way

The majority of Finns think that they are either aware of how to prevent the loss of biodiversity through their consumption choices or would like to know more about it (Eromäki 2022). Learning about these complex interconnections between human activities and the natural world could be a game changer: biodiversity is not only knowledge about biological facts but more. The novel concept of Education for Planetary Well-being considers the interdependence of the well-being of humans and non-human species and consequently enlarges the concepts of biodiversity and sustainable education (Aaltonen et al., forthcoming). Altogether, post-humanist educational thinking could be strengthened in education: considerations about the intrinsic value of non-human beings are largely missing from curricula (Keto et al. 2021). Educators could need further training in linking the extended idea of biodiversity to their teaching. The educational administration could allocate resources to teacher training and include biodiversity issues in curricula even more than before.

Teachers in basic education need support for biodiversity education. Environmental education professionals working in NGOs provide support, but the resources of NGOs are scarce. The local educational administration could allocate resources to the local support of educators. This is also in full compliance with the new Nature Conservation Act. To support all levels of education in biodiversity and sustainability education, some national coordination is needed. A governmental office that can operate as a link between educational and environmental administration would be a good solution. The decision could be made on the ministry level.

The Dasgupta Review (p. 498) suggests that universities should require new students to attend a course on basic ecology. This is a good suggestion in the Finnish context, too, and not only at the university level, but it should be included at all levels of education. The decisions on this matter could be made in each university. There are forerunners in Finland. For example, the University of Jyväskylä has decided to include an obligatory course entitled "Introduction to planetary well-being" in all degree programmes. In addition to obligatory courses, connections to biodiversity could be introduced in each degree programme. The Review argues that success in protecting and restoring the biosphere will ultimately depend on whether people are able to act collectively towards this goal, and education is surely one means of creating this ability and empowering citizenship (see also the Chapter 6.9 "Empowered Citizenship"). This is one target for Finnish education, too.

Information needs

Although biodiversity is somehow embedded in curricula, there have been no comprehensive assessments of the implementation or results obtained for biodiversity education. Environmental educators and teachers have developed a wide range of methods and pedagogies for biodiversity education, but the results are not adequately known. For example, it would be interesting to develop an ongoing evaluation system for nature school activities. The evaluation system could then also be applied in other contexts, such as in the everyday lives of basic schools.

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6.11 Summarizing and evaluating the options for change

The proposed actions under each option for change are summarized in Table 7. Their feasibility is evaluated by applying the following criteria and the levels defined:

Societal readiness: how prepared and capable are citizen/consumers, firms and administrations to act according the proposed action. Are there institutional examples?

- RED: none of the actors express readiness for action; no existing comparable institutions as an example
- YELLOW: some actors express readiness; some relative institutions exist for bench marking
- GREEN: several actors express readiness; many relative institutions exist that are functioning well

Stakeholder identification and involvement

- RED: difficult to identify stakeholders and co-creation with a heavy workload is needed
- YELLOW: difficult to reach all stakeholders, and a considerable workload in involvement (consulting, collaboration)
- GREEN: informing easily identifiable stakeholders is enough for successful involvement

Cost effectiveness: how the action will contribute to the overall goal of bending the curve of biodiversity loss and at what cost (=effort, also qualitative, not only €)

- RED: low positive impact on biodiversity and high cost or effort
- YELLOW: high positive impact on biodiversity and high cost, or low impact on BD and low cost
- GREEN: high positive impact on BD with low cost or effort

Time frame: timing of costs (=effort) and biodiversity improvement

- RED: immediate costs and very distant BD improvement
- YELLOW: costs immediately and BD improvement immediately, OR Costs in the distant future and BD improvement in distant future
- GREEN: distant cost and BD improvement immediately

Co-benefits: positive environmental, social or economic impacts associated with the implementation of the proposed action

- RED: no co-benefits
- YELLOW: some co-benefits to a low number of beneficiaries
- GREEN: several co-benefits that are widely enjoyed

Table 7. Evaluation of the proposed actions under options for change.

Proposed action under OC	Criteria				
	Societal readiness	Stakeholder identification and involvement	Cost effectiveness	Timeframe	Co-benefits
OC: Conservation and Restoration					
Stronger adoption of impact avoidance and its regulation in land use planning to reduce new negative impacts on biodiversity	Strong to moderate objection from the private sector, but also readiness. Supported by environmental NGOs and in some cases by residents.	Local to regional level decision-making. Involves broadly different stakeholder groups, but these are easy to identify, and the process is already established. Relevant institutions exist.	The most cost-effective form of conservation. Developers may face some additional costs from more careful planning and potential replacement of activities. Small additional resourcing may be required for the regulator.	BD benefits immediate. Potential costs to individual developers immediate. Costs to society reduced, as it reduces the need for more expensive protection and restoration in the future.	Recreation benefits and associated citizen well-being.
Expand voluntary, compensation-based protection programmes such as METSO	High societal readiness.	Stakeholders easy to identify. Some relevant institutions and processes already exist, although increased volume will require improved coordination between institutes.	Can be slow and expensive. Fewer options for the impactful placement of protection, as this depends on the willingness of landowners to participate. Risk of spending scarce resources on actors who would have maintained the BD values on their property anyway. However, may be key for the critical transition.	Costs and BD benefits constant.	Reduces conflicts and increases ownership and acceptance of conservation measures.

Proposed action under OC	Criteria				
	Societal readiness	Stakeholder identification and involvement	Cost effectiveness	Timeframe	Co-benefits
Improve the coordinated collection and the availability and use of biodiversity information	High societal readiness for relevant information, such as "no regrets" areas in planning and priority areas in conservation.	Stakeholders easy to identify but considerable workload in bringing together currently fragmented data collection and establishing smooth information transfer between institutions.	Setting up information transfer has high, mostly one-off initiation costs. Data collection costs continuous, although coordination may result in higher cost-efficiency. Biodiversity benefits large, as supports avoidance and strategic use of conservation resources.	Costs high at first but decrease over time. BD benefits immediate and increase over time.	Biodiversity accounting, monitoring (incl. climate change), reporting.
OC: Supply and Demand					
Decreasing subsidies for animal-originated food stuff production on a global scale	Strong objection from the producers of animal-based food stuffs.	Politicians and agricultural organisations.	Possibilities to save money.	Changes in agricultural policies take a long time.	Can be beneficial to society as a whole.
Incentives for the development of novel plant-based protein sources (lupine, mycoprotein, etc.)	Strong objection from the producers of animal-based food stuffs and/or their interest group.	Farmers and the food industry. Some actions are already underway.	Investments can be high in the beginning. Possible cost benefits could be achieved through better population health.	Changing farming practices can be a relatively slow process. Building new factories can also take a relatively long time.	Offers possibilities for food exporting, if implemented correctly.
Including the preparation of vegetarian/vegan dishes in the training programmes of catering professionals	Societal acceptance of vegetarian dishes has grown rapidly.	Vocational school teachers need to be activated and contacts with vegetarian cooks need to be activated.	Relatively low cost.	It can take several years before students enter working life.	Possible health benefits for the customers, if implemented correctly.

Proposed action under OC	Criteria				
	Societal readiness	Stakeholder identification and involvement	Cost effectiveness	Timeframe	Co-benefits
Creating nudges (e.g., better availability) and incentives to use plant-based foods in public restaurants	Societal acceptance of vegetarian dishes has grown rapidly.	Restaurants need to be activated.	Low cost.	Possible to implement relatively quickly.	Possible health benefits for the customers, if implemented correctly.
OC: Supply chains and trade					
Support the implementation of a non-discriminatory tax on both imports and domestic commodities based on their assessed biodiversity footprint in the EU	Stakeholders with a high BD impact are likely to be resistant. EU-level support needed but uncertain in the current political environment. BD footprint methodologies exist to assess the impacts of commodity groups, but further development needed.	EU-level decision but affects countries globally. WTO and large economies likely to be key stakeholders. Involving all stakeholders likely to be difficult.	High-impact industries will experience a rise in costs. Low-impact industries can gain a competitive advantage. Tax revenue will be created for governments. Natural capital will be increased.	Costs and revenue immediately and in the distant future. BD improvement immediately and in the distant future.	Revenue can be used to support transition and mitigation efforts of high-impact industries and support nature-positive industries and activities.
Initiate national policies and standardization of biodiversity footprint assessments in all organizations, starting from large organizations	Not many stakeholders are expected to be resistant. BD footprint methodologies exist and are being tested with several organizations. More development needed to ensure the use of uniform indicators. Some standards exist, but are not widely applied.	Large organizations with better resources can be reached more easily than small and medium-sized organizations.	Design costs are relatively low but implementation of BD footprint assessment in organizations will increase costs. BD gains depend on how organizations and public officials start implementing mitigation policies based on footprint analyses.	Costs immediately and in the distant future. BD improvement in the near and distant future.	Standardized assessment ensures that organizations do not have to use time to think about how to do the assessment correctly. Greenwashing options reduced. BD footprint assessment itself might not initiate required improvements in BD policies.

Proposed action under OC	Criteria				
	Societal readiness	Stakeholder identification and involvement	Cost effectiveness	Timeframe	Co-benefits
OC: Pricing					
Pricing negative externalities in the energy and transport sectors	Institutions are in place and well-functioning in terms of CO2 emissions. However, biodiversity loss pertaining to peat production, wood fuels, wind and hydropower are not priced. Extending pricing to biodiversity loss pertaining to these energy sources is likely to raise resistance in the relevant industries.	If considering entities to be taxed, stakeholders are easy to identify. National policymakers would be able to implement the changes required.	Biodiversity varies locally, which means that the social cost of activities causing biodiversity loss would need to be assessed accounting for local site characteristics. Correctly pricing biodiversity impacts would require reliably assessing both the local effect of the activity on biodiversity and the local value of biodiversity. The information needs are vast.	Local extinction of species can occur with substantial delay following habitat loss or degradation. If one perceives the costs as forgoing an energy-related project that would cause biodiversity loss with a delay, the costs would start running immediately but would be spread over time; the benefit in terms of avoiding biodiversity loss might be in the distant future. However, delay is not always present.	Co-benefits in terms of avoiding CO2 emissions from peat and wood fuels. On the other hand, there are trade-offs in terms of wind and hydropower – avoiding biodiversity loss could lead to more CO2 emissions.

Proposed action under OC	Criteria				
	Societal readiness	Stakeholder identification and involvement	Cost effectiveness	Timeframe	Co-benefits
OC: Future population					
Accelerating the demographic transition in developing countries	Finland has an ODA budget allocated to supporting development in least-developed countries. However, increasing (needed) or changing the ODA allocations can raise resistance.	Decisions can happen at many levels depending on the chosen strategy (through ODA, international lobbying, or business and trade). Taxpayers (and elected politicians) can oppose using funds for this cause.	Cost-effectiveness of the action depends on the chosen modality to affect the future population. According to the literature, the most cost-effective means to curb population growth are SRHR projects, girls' education and gender equality/ empowerment.	For population growth, SRHR interventions are fast but limited in scope, education is usually more universal, and empowerment is slower due to having to change many aspects, such as social norms and behaviours.	Any action that accelerates demographic change from high population growth to the next steps will bring about longer, healthy lives and lower mortality with more surviving children. This means fewer people, less suffering and greater well-being for humanity. However, ensuring that everyone has the same higher living standards will be a problem for biodiversity.

Proposed action under OC	Criteria				
	Societal readiness	Stakeholder identification and involvement	Cost effectiveness	Timeframe	Co-benefits
OC: Measures of economic progress					
Producing national natural capital accounting and integrating nature into national accounting	Not likely to raise a lot of resistance, as the issue has been discussed for decades. However, there is another stream of discussions that would like to see the use of GDP removed from decision making altogether.	Ministries, research institutes, producers of official statistics. Developing the framework and starting production requires a lot of cooperation between the organizations involved. Other stakeholders need to be involved in mapping information needs.	Difficult to estimate costs and benefits, the costs of implementation can vary significantly together with the ambition level of the measures chosen. On the other hand, would also save costs by enabling better and more effective policy making. The effectiveness of the action will depend on how the information is used by decision makers.	For efficient monitoring, long time series of data and consistent regular production are essential.	Will provide monitoring indicators for issues besides biodiversity, such as climate change and resource efficiency.
OC: Global Public Goods	**Societal readiness**	**Stakeholder identification and involvement**	**Cost effectiveness**	**Timeframe**	**Co-benefits**
Using the "environmental leader image" to support more stringent and clearer international institutions for biodiversity (GPG) policy (e.g., "Global Marshall Plan for Biodiversity")	Unlikely to raise a lot of resistance, as this takes place at the level of international politics and does not directly concern wide groups of societal actors in Finland.	National and EU-level politicians and authorities are the key; NGOs and the scientific community as lobbyists.	Costs for this action are relatively low, but implementation of more stringent BD will be costly.	Costs not significant in the short term, might be higher in the longer term, but payoff in terms of improved BD policy and BD protection (GPGs in particular).	Improved dialogue, clearer rules.

Proposed action under OC	Criteria				
	Societal readiness	Stakeholder identification and involvement	Cost effectiveness	Timeframe	Co-benefits
Using the experience gained in the Baltic and Nordic cooperation for the Arctic (and other GPGs)	Unlikely to raise any resistance at any level of society.	Regional governmental and NGO networks and organizations could be engaged on top of the obvious governmental actors.	Win-win (?).	Both short term and longer term.	Spin-offs outside the Arctic context.
OC: Global financial system					
Integration of biodiversity into the fiduciary duties of institutional investors and asset managers	Unlikely to raise wider public resistance but some resistance among financial market participants. Models available from France.	To be developed in co-operation with institutional investors.	Relatively low costs of developing the processes. Biodiversity impacts difficult to predict.	Impacts on funded businesses on short run. Biodiversity impacts on longer run.	Can be integrated with climate actions. Spin-offs to other sustainability issues.
Assessment of the biodiversity risks, benefits and opportunities required from public actors on financial sector	Unlikely to raise wider resistance at any level of society. Both financiers and recipients of funding need the support of expertise.	Can be developed inside public sector.	Relatively low costs of developing the processes. Biodiversity impacts difficult to predict.	Impacts on funded businesses on short run. Biodiversity impacts on longer run.	Can be integrated with climate actions. Spin-offs to other sustainability issues.

Proposed action under OC	Criteria				
	Societal readiness	Stakeholder identification and involvement	Cost effectiveness	Timeframe	Co-benefits
OC: Empowered citizenship					
More even distribution of green spaces to guarantee easy access to them for everyone	People usually value green spaces highly, but conflicts may appear when other societal needs and goals put pressure to decrease green spaces. This is especially the case in urban land use planning, where the pressure is strongest and most green areas are currently located on the outskirts of cities.	Allowing construction on existing green areas is easier to push through in ***lower income*** areas in municipal land-use and policy processes than in better-off areas. Thus, existing planning policies seem to have unequal distributional effects on the possibilities to enjoy green spaces and nature-based recreation.	Impacts on biodiversity protection are often ***indirect*** and also require efforts in other citizenship empowering activities.	Since BD benefits are indirect, they might take more time to occur, while the costs in land use planning in terms of other societal needs and goals are more immediate.	Recreational, well-being and health benefits.
Shift toward more adaptive management practices in which citizens are involved in the continuous process of (re-)design and maintenance of green spaces and in which their local knowledge, experiences and emotions are acknowledged	Requires changes in existing planning and management practices and in the mind-set of the planners.	Most of tools for successful involvement are already there; the question is more about reorienting them.	Direct impacts on BD protection and maintenance. Relatively modest cost if existing processes are successfully expanded to active maintenance (instead of planning).	Can have a strong local impact on the maintenance of BD, even in the short term.	Improve the implementation and knowledge base of BD protection.

Proposed action under OC	Criteria				
	Societal readiness	Stakeholder identification and involvement	Cost effectiveness	Timeframe	Co-benefits
Diversification of the range of opportunities for citizen participation. From easily accessible mobile phone apps to more action-based participation to protect biodiversity (e.g., citizen science, civil/political activity)	Easily accessible mobile phone apps and GIS information, such as iNaturalist.laji.fi, are actively used by ordinary citizens to report sightings of species and upload observations to databases, such as the Finnish Biodiversity Information Facility. New tools are, however, needed to enhance the pro-BD behaviour of these 'simple activities'.	The main challenge is to design the management and decision-making processes so that they recognise the diversity in citizen's expectations and capacities for BD participation.	Citizens' nature activities contribute to their pro-biodiversity behaviour when these activities at the same time enhance their connectedness with nature, i.e., involve their "physical senses of sight, sound, smell, and touch." This requires more efforts in the design and implementation of participation. On the other hand, improving opportunities for civil and political activity for BD does not cost much.	Can have a strong local impact on the maintenance of BD, even in the short term.	Improve the implementation and knowledge base of BD protection.
New innovative tools, such as deliberative minipublics, to enhance the representative participation of citizens	Decision-makers and public officials who do not have confidence in the capacity of citizens to engage in discussions on complex issues such as BD.	Representative random selection may sometimes require oversampling of disempowered groups, e.g., minorities.	When used in the local context, may have direct BD impacts. More generally, benefits are indirect, while the costs of organising minipublics are considerable.	More indirect impact on BD, while enhancing the legitimacy of BD governance in the long term. However, immediate inputs to political decisions on BD are possible if tools are appropriately connected to existing decision making institutions.	Improved mutual trust and societal acceptance of BD policies.

Proposed action under OC	Criteria				
	Societal readiness	Stakeholder identification and involvement	Cost effectiveness	Timeframe	Co-benefits
OC: Education	**Societal readiness**	**Stakeholder identification and involvement**	**Cost effectiveness**	**Timeframe**	**Co-benefits**
On different levels of education, strengthening the further training of teachers in biodiversity	Many teachers interested in environmental issues are ready to learn more about biodiversity, but many teachers have other priorities. There are many competing issues that educational administration is asked to allocate training resources to.	Educational administration and teachers are easily reached through municipalities, universities, or other education providers and the Ministry of Education and Culture, but it is difficult to engage people with many competing objectives.	Learning of teachers enables teaching and learning of students. Learning of teachers in training courses benefits students during the whole career of teachers, so the price per student of one teacher is minimal.	Costs of training courses are immediate. The improvement in biodiversity will happen partly immediately (after learning you can make informed decisions in your personal and work life straight away) and partly in the future (training of all teachers takes time, and teachers can teach for decades, so future students are also involved).	Teachers can support not only students, but also their peers in educational organizations. The connections with other environmental issues can also be taught when talking about biodiversity.

Proposed action under OC	Criteria				
	Societal readiness	Stakeholder identification and involvement	Cost effectiveness	Timeframe	Co-benefits
Allocating resources locally to biodiversity education and connecting with nature, and setting up a national coordinator for biodiversity and sustainability education	Biodiversity education professionals, for example in NGOs, are ready to give support to schools within the limits of their resources. To increase the support, more resources should be allocated to local actors such as nature schools providing biodiversity education and experiences in connecting with nature. Some municipalities maintain nature school activities, but many municipalities do not have such activities. National educational organisations are not enthusiastic about coordinating biodiversity and sustainability education.	Biodiversity education professionals and municipalities are easy to reach through national networks. In the municipalities, the political agreements of allocating resources to biodiversity education could be difficult to achieve. Either the Ministry of Education and Culture, the Finnish National Agency for Education or the Ministry of the Environment are the key actors as coordinators.	Local biodiversity education professionals improve the availability of support in the everyday life of educators. The price per student is minimal. The cost of the national coordinator for biodiversity and sustainability education is not high compared to many other incentives.	Costs of allocating resources to biodiversity education are immediate. The improvement in biodiversity will happen through behavioural change and the competence of the learners, partly immediately and partly in the future.	The same biodiversity education professionals are also experts in many other types of environmental and sustainability education, so resources allocated to them benefit all planetary well-being education. All fields of education will benefit from the work of a national coordinator.

Proposed action under OC	Criteria				
	Societal readiness	Stakeholder identification and involvement	Cost effectiveness	Timeframe	Co-benefits
Setting an obligatory course on basic ecology in every educational institution and finding connections to biodiversity in every degree programme	Through the statements in global and national strategies and agreements, biodiversity is receiving increasing attention, which motivates the inclusion of biodiversity and sustainability in curricula. However, there is strong competition over the contents of curricula of educational institutions.	Universities are reached through ARENE and Unifi networks. Agreements between the Ministry of Education and universities could include demands for obligatory courses and finding connections to biodiversity in degree programmes. In vocational education, the Finnish National Agency for Education can be the driver for defining new qualifications in vocational education.	No additional costs – but additional efforts in allocating money to different issues than before. It would be a very cost-effective way to minimize biodiversity loss if all the professionals had competence regarding the impact of their professional activities on biodiversity and ways to avoid biodiversity loss.	The improvement of biodiversity will happen through behavioural change and the competence of the learners, partly immediately and partly in the future.	Newly qualified professionals can deliver information to their workplaces. Competence in biodiversity and sustainability can be widely applied in multiple activities.

Table 7 of possible actions based on the options for change presents evaluations of the feasibility of implementation. Even though the evaluations are provided by different experts and the scale cannot be fully standardized, we can see that some of the criteria are satisfied better than others. For the majority of actions (21/23), several co-benefits that are widely enjoyed are identified. These associate with other environmental benefits, health benefits and other social benefits, such as a knowledge base, expertise and trust in society. Especially in societal readiness and in the need for stakeholder involvement, actions were evaluated in the middle category, indicating some societal readiness and the existence of some institutional benchmarks, as well as difficulties in reaching relevant stakeholders and a considerable workload in their involvement. In cost-effectiveness, the middle category was rather typical, representing a high positive impact on biodiversity but a high cost, or a low impact on biodiversity with a low cost. Promisingly, many actions with a high positive impact on biodiversity but a low cost or effort were also identified. The majority of actions could be evaluated in the middle category in the time frame of costs and benefits, implying costs immediately and biodiversity improvement immediately, or costs in the distant future and biodiversity improvement in the distant future. The best category in this criterion, i.e., distant cost and immediate BD improvement, collected few actions.

The actions are presented on the rather general level of ideas and need to be specified more in detail. The specification of actions will also allow stakeholder discussion, co-development and new ideas to come up that may ease the implementation of actions. Table 8 presents two sectoral examples, from agriculture and forestry, of how the actions presented under each OC can be targeted in each sector. The sketches presented in Table 8 present ideas for starting points. In each sector of society, cooperation is needed to further develop socially acceptable, institutionally feasible and highly cost-effective measures in each OC.

Table 8. How to incorporate ideas from options for change in key sectors: examples from the forest sector and the agriculture and food sector.

	Forest sector	Agricultural and food sector
Supply of nature	Expansion of voluntary, compensation-based protection programmes such as METSO Creation of incentives and new mechanisms for biodiversity conservation in private commercial forests	New mechanisms to secure the conservation of traditional rural biotopes
Consumption and production patterns	Increased wood construction, e.g., in public sector projects Further enhanced cascade use of wood	Promoting the shift to plant-based diets, and support for the innovation of new foods and related changes (Ch. 6.2)
Supply chains and trade	Certification, EU legislation	Biodiversity footprint information to consumers for both imported and domestic foods
Pricing externalities	New economic incentives to forest owners to maintain and increase biodiversity Biodiversity market creation, supported, e.g., by legislation Economic incentives to forest machine operators to succeed in nature-oriented forest management	Taking externalities into account in subsidies paid under both pillars of the EU CAP. A negative biodiversity impact of a subsidized activity would decrease the subsidy
Population	Taking population growth, education of girls and gender equality issues into account in forest-related development projects	Taking population growth, education of girls and gender equality issues into account in agriculture-related development projects
Measuring	Forest ecosystems as part of the development of ecosystem accounting and possibility for related pilot projects	Agri-ecosystems as part of the development of ecosystem accounting and related pilot projects
Financing	Participation in the development of the EU taxonomy for the forest sector Biodiversity prerequisites for funding forest investments	Participation in the development of the EU taxonomy for the agricultural and food sector Biodiversity prerequisites for funding agricultural investments

	Forest sector	Agricultural and food sector
Global public goods	Active participation in international processes to support more stringent and clear international institutions for biodiversity, especially in land use changes from forest to agricultural land and for forest degradation.	Active participation in international processes to support more stringent and clear international institutions for biodiversity, especially in land use changes from forest to agricultural land.
Empowering citizens	Use of deliberative minipublics in forest planning of municipalities and Metsähallitus. Ensuring a wide possibility for participation, e.g., with easy access mobile apps.	Creating opportunities for citizen participation in setting the regional goals for biodiversity in agricultural environments.
Education	Increased education on forest biodiversity and nature-oriented forest management to forest machine operators.	Further education in the agricultural and food sector to integrate biodiversity into professional knowledge bases.

7 Discussion of results and policy implications

The Dasgupta review frames global biodiversity loss as a looming emergency, threatening the stability and economic well-being of our societies. Becoming aware of the emergency and being able to identify its state and drivers is necessary for reversing the trend of biodiversity loss. However, it is not enough. Regardless of how well we shed light on the problems and how successfully we raise awareness, we still need to modify societal structures and processes if we want something to change. The root cause of biodiversity loss is that our public and private decision-making, including political and economic, does not take biodiversity sufficiently into account. The social costs of the generation of pollutants are not sufficiently included in economic decision-making, and there are not enough incentives for the generation of public goods, such as nature protection areas. In the long term, our welfare depends on biodiversity. However, biodiversity loss itself does not generate the incentives needed to stop our economic systems, by design, from devouring natural capital and thereby the wealth of future generations. We need to actively adjust the design flaws in many societal levels of decision making. Clearly reasoned adjustments are needed from policy makers, owners and directors of businesses, landowners, households, citizens and consumers.

As ecosystems, biodiversity and social conditions and opportunities vary geographically, the options for change suggested by the Review call for a national assessment that considers the national ecological conditions, dependences of nature and socio-cultural aspects. In this assessment, we continued on the path signposted by Dasgupta. From the national perspective, we illustrated the impacts of the Finnish economy on local and global biodiversity. We also provided examples of the dependencies of the Finnish economy on ecosystem services and biodiversity. Based on the work of the scientific panel of experts, we concretized what the options for change mean for Finnish citizens and governmental, regional and commercial actors. We have identified the actors responsible for each of these changes in Finland and discussed the feasibility, information and time requirements for such changes.

We identified crucial information needs in determining the national biodiversity footprint. Even though international studies exist that also include Finland, there are no established footprint measures or processes to follow the footprint in a time series, or the drivers behind them. Although several indicators used in the literature provide varying evidence of our national footprint, the general tendency is that the national footprint in absolute terms is moderate in international comparisons, but if related to the size of the population, the Finnish footprint is, unfortunately, on a high level. We, among other countries with high living standards, have outsourced the biodiversity impacts to other countries, and especially problematically to low-income countries that extract minerals and produce materials for our consumption.

The importance of agriculture and forest sector was emphasized in this assessment due to our land uses. The biodiversity effects of forestry mostly occur in Finland, as the Finnish forest industry mostly uses domestic wood. The driving force for the use of Finnish wood is consumption outside Finland, as a significant share of production of the forest industry is exported. Finland is among the major producers of forest industry products in the world, and the import of forest industry products is marginal. Through changes in ecosystems (e.g., ditching of mires, changes in forest age structure), forestry has caused significant changes, especially in the biodiversity of forests and mires in Finland, but has also impacted on waters. Public incentives for private forest owners currently emphasize wood production, although the climate and biodiversity aspects are widely discussed and brought forth in decision agendas. In governing forest biodiversity, in addition to strict nature conservation, special emphasis should be given to increasing biodiversity measures in commercial forests. As the majority of forest land is owned by private persons, the objectives, values, knowledge level and consequent forest management practices of private forest owners have a significant impact on biodiversity. The state of biodiversity is highly dependent on the content and success of public incentives, but beyond the financial policy tools, the role of information guidance cannot be overemphasised.

In agriculture, the effects on biodiversity are driven by land use change and by production technologies. The most significant effect comes from land use: land allocated to agriculture replaces natural habitats. On the other hand, landscape-level changes date back millennia, making agriculture also a proponent of biodiversity. Indeed, many of the endangered habitats in Finland are related to traditional farming systems, particularly grazing. In recent decades, the agricultural land area in Finland has remained stable. However, we import more food products and animal feed, which has increased the biodiversity effects of agriculture in other countries. Of the local negative effects, the indirect effects on aquatic biodiversity, in particular, are important. Agriculture is the most important anthropogenic source of nutrient loading, causing eutrophication in surface waters. Forestry has similar indirect biodiversity effects on surface waters. In addition to nutrient loading, it also contributes to the brownification of waters, impairing freshwater biodiversity in particular. In governing agricultural biodiversity, the key is in the design and implementation of the CAP, its biodiversity measures, and measures for the conservation of surface waters. It is also essential to avoid an increase in the land area for agriculture.

Municipalities are the gatekeepers for land use changes, from forestry and agriculture to housing, traffic and industrial uses. In land use decisions, it is particularly important to take biodiversity and other non-market benefits of green areas into account, possibly in monetary terms, to consider all the relevant costs of development projects. The European Biodiversity Strategy for 2030 and its forthcoming Restoration Law give reasons not to diminish the land cover of urban green space and its biodiversity potential.

The structures, processes and functions of ecosystems, supported by biodiversity, are the basis for the production of a variety of ecosystem services. However, in many cases, it is not well known how changes in biodiversity will impact on the formation of ecosystem services. For livelihoods such as agriculture or forestry, biodiversity has potentially high importance. The richness of biodiversity can affect forest productivity and it most probably increases the resilience of forest ecosystems. Resilience is of importance to economic sustainability, as natural disturbances (e.g., forest fires, storms, pest-insect outbreaks, fungal infestations) create forest damage, negatively affect forest growth and cause economic losses. In agriculture, maintaining or losing soil biodiversity has direct consequences for the maintenance of soil fertility, productivity, and economic performance by promoting or hampering food production. However, quantitative estimates of the economic effects of biodiversity loss are scarce both in the agricultural and forest sector. There is still much we do not know about the impacts of biodiversity loss. However, in Finland, as elsewhere in the world, economic activity is dependent on healthy and well-functioning ecosystems, and in the long term, biodiversity loss will deteriorate this basis.

In addition to effects on livelihoods, biodiversity also affects the well-being of Finns in many other ways. Contact with natural environments and especially those rich in biodiversity has been found to enrich the human microbiome, promote immune balance, and protect people from allergies and inflammatory disorders. Furthermore, experiences in nature are the key motivators for outdoor activities. The link between biodiversity and recreational activity, however, is less clear, even though the number of visits to national parks, for example, is associated with the diversity of nature. Beyond the number of visits, the diversity of nature typically increases the well-being effect of outdoor recreation. The economic value people assign to the presence of biodiversity in different ecosystems, i.e., the existence value of biodiversity, has been measured with citizen surveys. These values need to be routinely incorporated into the costs–benefit calculations of biodiversity protection, although value estimates are typically study-specific.

During the assessment, several strategic and legislative processes were ongoing. The European Commission’s proposal for the Nature Restoration Law was circulated for statements. The Finnish Nature Conservation Act was debated, voted on and agreed upon in the Finnish parliament. The Ministry of the Environment was preparing the Biodiversity

Strategy and Action Plan for Finland. In addition, the Ministry of Finance prepared its strategy for climate and biodiversity. NGOs were active in preparing their stands on nature loss and its prevention. For example, the biodiversity strategy of the Central Union of Agricultural Producers and Forest Owners was under preparation. The Finnish Nature Panel assessed several aspects of nature loss in Finland. All this overlapping strategy building will lead to new ideas and initiatives on how to implement the options for change presented by Dasgupta.

In the options for change section, we focused on all the targets identified by the Dasgupta Review: the balance of supply and demand, measures of natural capital and the development of our institutions. According to the expert evaluation of options for change, all of them could be implemented in Finnish policies.

The ***supply of biodiversity*** could be supported with several measures, such as carefully targeted suitable conservation locations, effective payments for ecosystem services (PES) schemes, and novel nature-based solutions. The economic costs of meeting any meaningful targets to reverse biodiversity decline in Finland can be relatively high; a 15% improvement in the conservation status of terrestrial habitats is estimated to cost an additional 445 million euros per year. Kniivilä et al. (2022) estimated that if the area of strictly preserved forest would be increased to 16% of forest land, the decrease in value added could be 540–1 150 million euros/year. One key measure is the adoption of the mitigation hierarchy. According to this procedure, biodiversity losses from human activities must first be avoided, after which remaining harm must be minimised, and after these two stages, any remaining losses must be ecologically compensated. The practice of ecological compensation (biodiversity offsetting) will make the accounting of losses and gains more transparent and effective, since the potentially high cost of offsetting will motivate development planners and decision-makers to seek better avoidance and mitigation options. In the accepted Nature Conservation Act, to be enforced in 2023, ecological compensation will be voluntary, not mandatory.

From the other options for change to balance the demand and supply in shifting ***production and consumption patterns***, our focus was on increasing the share of plant-based foods, which also has many co-benefits beyond biodiversity, not least climate change mitigation. Substantial changes were perceived as possible, although population-level changes in consumption happen slowly. Subsidies for different parts of production chains from farms to food innovations can enhance biodiversity-respectful change. Concerning ***supply chains***, biodiversity footprint assessments need to be developed at the organizational level to measure the holistic biodiversity footprints of supply chains and to facilitate mandatory biodiversity footprint assessments in all organizations, starting from large organizations. ***Trade*** policies targeting biodiversity are possible but call for international co-operation to agree on border adjustment taxes, or support for sustainable commodity import guarantees. ***Pricing*** biodiversity impacts would change profitability calculations and investment decisions. Information gaps challenge the development of the pricing of biodiversity externalities, as biodiversity varies locally, biodiversity impacts are often discontinuous and value information for biodiversity changes is needed. Targeting policies pertinent to ***global population growth*** is strongly dependent on the political will to budget to development assistance that focuses on women's empowerment, rights and education, with a special focus on sexual and reproductive health and rights.

To make the importance of biodiversity, ecosystem services and natural capital visible, the development of ***measures*** of welfare is necessary. To implement the continuously developing System of Environmental Economic Accounts and the EU regulation for accounting, international standards are followed in Finland. Beyond the national pilots, being active in international forums will ensure that the statistical frameworks and guidelines will be relevant to our national information needs. Furthermore, integrating the measures of natural capital into the decision-making process is crucial to create a change in the assessment of welfare impacts and to integrate biodiversity impacts into decision making in the future.

Developing our institutions as suggested by Dasgupta requires international co-operation but also national initiatives. In the case of ***global public goods***, Finland's image as an international leader of environmental solutions could be restrengthened and utilized to promote policy actions such as the Global Marshall Plan for Biodiversity. In addition, Baltic and Nordic co-operation can provide institutional models to enhance the co-operation regarding Arctic biodiversity. In developing institutions for a ***financial system*** to account for biodiversity, active participation in international processes is needed, but at the same time, several promising alternatives exist to continue the development in financial markets on the national level. Institutional investors such as pension funds can voluntarily pay attention to biodiversity issues. Public funders can require the assessment of the biodiversity risks, benefits and opportunities of their funding decisions. Furthermore, in public procurements, biodiversity can be accounted for among the other sustainability aspects.

An institutional option for change that can be encouraged and enabled on the national level is ***empowering citizens*** to act for biodiversity. Democratic innovations, such as minipublics, can promote changes that are also accepted by a wider audience and various citizen groups with different interests. Several of the previous options for change demand pedagogical innovations leading to education and knowledge building among citizens, but also among various stakeholder groups. In all levels of ***education***, teachers need support for including biodiversity in teaching and learning materials. One option would be obligatory courses that incorporate biodiversity in degree programmes. To support education in biodiversity and sustainability issues, local allocation of funds and national coordination is needed.

In this report, we relied in expert assessment of the options for change, which is the only realistic approach to cover the wide spectrum of possible policy actions. A considerable amount of uncertainty in existing information and information needs was observed. Although biodiversity was a new field of application for some of the experts, the expert-based approach to national assessments can be recommended. The expert information was complemented with a stakeholder participation process. As biodiversity has not previously been a focus of attention of many relevant stakeholders, it was challenging to endure that all the relevant angles were identified, represented and discussed. The strongest stakeholder interest seemed to focus supply and demand aspects of biodiversity, and to lesser extent on environmentally oriented measurement of welfare and institutions.

As concluding remarks, the national assessment of the Dasgupta Review has demonstrated the need to change biodiversity-related actions by **all actors**. All economic sectors possess control over some of the links to nature loss, and all levels of decision-making and administration have possibilities and responsibilities to undertake such actions. In addition to the public sector, the private sector, including various NGOs, also has responsibilities. Several of the analysed options for change showed that it is of high importance to be **proactive in international processes and simultaneously develop and test forerunner measures nationally**. Furthermore, beyond the national policies, local and individual actors can be activist trailblazers and developers of novel courses of action for wide use.

In the evaluation of the options for change, we recognized **societal readiness** and **cost-efficient** actions with a high positive impact on biodiversity and a low cost or effort. **Co-benefits** that are widely enjoyed were identified and associated with most of the identified actions. Several information needs were recognized, but delaying actions until the full scientific evidence is available is not without costs. These information needs concerned knowledge, ranging from ecological causalities to value information. Although it is impossible to put economic price tags on biodiversity in its various levels and locations, its **value can be identified and integrated into decision-making (e.g. IPBES 2022).** Nevertheless, it is necessary to enhance biodiversity programmes and policy measures under the conditions of **imperfect information** and find ways to make policy plans, decisions and concerted implementation before more research information is produced, i.e., to act according to the precautionary principle and tolerate uncertainty in decision-making. Even without the full evidence, we can anticipate whether the general direction of actions is reasonable and right. Future information will allow adjustments towards more fine-tuned and optimal decisions.

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